

THE BIG SCIENCE ISSUE

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THE 10 MOST AWE-INSPIRING PROJECTS IN THE UNIVERSE

THE ULTIMATE TELESCOPE LASER PARTICLE ACCELERATOR ORBITAL LAB COLLIDER UNDERSEA OBSERVATORY AND MUCH MORE

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SHIPPING GETS A MEGA-UPGRADE

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Why You'll Live to 150 p.50

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See the whole picture with Samsung ACTIVE 3D.

SAMSUNG

The Wonder of Samsung



The choice for 3D TV is clear - Samsung ACTIVE 3D.

Featuring 3D in Full 1080p HD resolution, Samsung ACTIVE 3D with ACTIVE 3D glasses makes every seat in your living room the best seat in the house. Samsung ACTIVE 3D delivers Full 1080p to each eye, as compared to PASSIVE 3D technology, which reduces the resolution to 540p to each eye. When deciding between Samsung ACTIVE 3D and PASSIVE 3D, the decision is simple. That's the Wonder of Samsung.

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The choice for 3D TV is clear – Samsung ACTIVE 3D

3D is the latest feature on premium HDTVs that gives users the capability to display three-dimensional images from 3D content. Right now, alongside a growing catalog of 3D Blu-ray movies, an increasing amount of 3D programming is available on cable and pay-per-view. And new 3D films and shows are being made all the time. All you need is a 3D-capable TV, 3D glasses, and a 3D content source.

It's the resolution.

Two common types of 3D technology are widely available for home use – ACTIVE 3D technology and PASSIVE 3D technology. There are many differences between ACTIVE 3D and PASSIVE 3D technology, but the primary variance is the quality of the home 3D experience. PASSIVE 3D technology uses glasses that effectively cut 1080p resolution in half (540p). Samsung ACTIVE 3D glasses deliver Full 1080p HD resolution to both eyes, doubling the resolution of PASSIVE 3D.

According to DreamWorks Animation CEO Jeffrey Katzenberg, quality is what matters when it comes to 3D. "DreamWorks Animation has always been dedicated to creating movies of the highest quality and, since 2009, we have been the only studio to exclusively produce films in 3D. So, it is tremendously important to us that 3D in the home must also be of the highest quality. This is why Samsung is our consumer electronics partner of choice.

Samsung's active 3D TVs offer the best in-home 3D viewing experience. Their full-resolution 3D TVs deliver to the home the same immersive 3D experience that our filmmakers intended for our audiences. By contrast, passive 3D TVs generate only half the resolution, resulting in a compromised viewing experience. Day after day, Samsung's R&D team keeps redefining state of the art. We are extremely proud to be their partners, as they lead the way in bringing the 3D revolution into the home."

"Samsung's active 3D TVs offer the best in-home 3D viewing experience."

– Jeffrey Katzenberg, CEO



So if you want to see the whole picture, Samsung ACTIVE 3D is really the only choice for you.

Advantages of Samsung ACTIVE 3D glasses.

Turning heads left and right, Samsung's stunning ACTIVE 3D glasses are engineered to sync seamlessly with your Samsung

TV and deliver an exceptional 3D viewing experience. They are lightweight, comfortable, and will last for up to 60 hours on a single battery charge. The cutting-edge technology and style of Samsung ACTIVE 3D glasses make Full 1080p HD possible at home.

"We expected this difference... We just didn't expect it to be so obvious... It makes you appreciate how good 1080p looks to each eye."

– David Katzmaier, Senior Editor for HDTV



Beware the black bars.

Samsung ACTIVE 3D technology consistently displays a 1080p HD experience to each eye. PASSIVE 3D TVs are known to be susceptible to the "venetian blind effect." When viewing 3D content on a PASSIVE 3D TV, it is not uncommon for faint black lines to appear horizontally from the top of the screen to the bottom. This effect does not occur with Samsung ACTIVE 3D technology.

Angles don't matter.

Where you place your TV in a room may not always be a matter of feng shui. A lot depends on how the picture looks when viewed from different angles. And while PASSIVE 3D technology tends to lose its 3D image quality at relatively short vertical angles (about 20 degrees), Samsung ACTIVE 3D delivers great results from almost anywhere in the room. No matter whether you are sitting, standing, or lying down on the couch to watch TV, Samsung ACTIVE 3D technology delivers a great 3D picture – even from angles up to 178 degrees!

An obvious difference.

Experts agree that when it comes to 3D, ACTIVE 3D technology consistently delivers outstanding quality. In a recent column for CNET.com, Senior Editor for HDTV David Katzmaier echoed these sentiments.

"We expected this difference... We just didn't expect it to be so obvious... It makes you appreciate how good 1080p looks to each eye," said Katzmaier in reference to the overall 3D quality that ACTIVE 3D technology delivers. (Crave news, CNET.com, January 20, 2011)

Samsung ACTIVE 3D technology consistently delivers Full HD 1080p resolution, overall image quality, and viewing versatility that consumers should expect in a home 3D experience. See the whole picture today with a Samsung ACTIVE 3D HDTV.

SAMSUNG

To see our full line of 3D HDTVs visit samsung.com

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Like the ancient redwood is *just* a tree.



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OR NOTHING.**

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AUGUST '11
VOLUME 279 #2

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We've found the 10 grandest science projects on Earth: the ultimate laser, telescope, undersea observatory and more.

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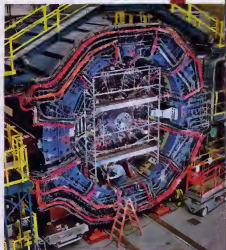
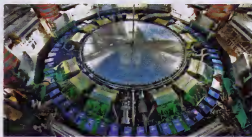
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Bill Andrews says he can develop a drug that halts aging. There's just one hitch: No one knows if it will kill us or make us live longer. **By Joseph Hooper**

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Cargo shipping is undergoing a major overhaul that includes new routes, bigger, more fuel-efficient ships, anti-piracy innovations and even the expansion of the Panama Canal. **By Rena Marie Pacella**



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POPSCI.COM

THE FUTURE NOW

THE BIG NUMBERS BEHIND THE LIST

Find out how we crunched the data to rank the 10 biggest science projects on Earth [page 38] at popsci.com/twitf.

► JEEPERS CREEPERS

Have an irrational fear of lots of little holes? Do lotus plants [right] freak you out? You might suffer from one of the newest phobias. Learn more at popsci.com/tryophobia.



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Palm Coast, FL 32142-0235THE END
OF AGING?

I'M WRITING THIS LETTER two days after the four-year anniversary of my mother's death. Also, as it happens, four days ago we drove to the cemetery to visit my wife Liza's mother's grave, a year after her death. And today is my birthday. I'm 46. Not so ancient, but I definitely feel more than a day older with every day that passes. You might say that I am a particularly invested reader of one of our big stories this month, "The Man Who Would Stop Time" [page 50]. In fact, once you get past a certain age, it's hard to imagine not rooting for a molecular biologist who's obsessively searching for the cure to aging, believing that when he succeeds, a normal human life span could shoot up to 150 years.

Last Saturday, I was engaged in some last-minute back and forth with the writer of this feature, Joe Hooper, who is 54 years old and is one of my best friends. I told him I would be out of pocket for a while because Liza

WHO WOULD
NOT ROOT FOR
A MOLECULAR
BIOLOGIST WHO'S
OBSESSIVELY
SEARCHING
FOR THE CURE
TO AGING?

and the boys and I were heading up to Mount Hope to visit Sandy's grave. "A year!" Joe wrote back. "That frightens me. It seems like it was only about two months ago that I ran into Liza a week or so after her mother died. Keep at it, Bill."

Bill Andrews, the subject of Joe's story and the object of his exhortation, says he believes that an enzyme called telomerase can prevent aging, and that if he can boost its production in humans he'll interrupt the self-reinforcing spiral of decay that saps our vitality as we grow older.

It might also help prevent cancer (which is what killed my mother-in-law); then again, it could fuel the uncontrolled replication of malignant cells. No one knows for sure.

Andrews's single-minded devotion to the telomerase theory has earned him some skepticism from scientific peers wary of the effect such passion can have on objectivity. It's a worthy point—but as an interested observer to the battle against aging, I find it difficult to criticize his dedication. After all, if he succeeds, the evidence will be pretty hard to dismiss. Keep at it, Bill.

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THE INBOX

INVENTION AWARDS

In June, we honored the year's 10 best inventions, examined the evolution of the bedbug, and suggested hiring robots to dispense medication in hospitals. As usual, we received plenty of feedback.

A Family Tradition

About a year ago, I subscribed to *POPULAR SCIENCE*. My father, James Crenshaw, who died in 1986, read your magazine frequently as a child and as an adult (he was born in 1924). He used to tell me about crazy, visionary ideas when I was growing up—cars that run on electricity, telephones you can carry around in your pocket, TVs that you can hang on the wall or watch while walking around, and electricity that comes from the sun. I thought Dad was totally nuts, but he would show me pages from your magazine that foretold these inventions. I now understand the fascination he had with *POPULAR SCIENCE*. So I'm a subscriber for life, and maybe I'll buy my nieces and nephews a few gift subscriptions too. Reading it lets me visit my dad for a few minutes. Thanks for being around for so long.

Billie Sue Crenshaw
Arlington, Tex.

Are Bedbugs Invincible?

"The Evolving Bedbug" [Headlines] made clear that we're all but helpless against this enemy. This is a problem that must be addressed soon. More funding should be allocated for research into new, effective and safe chemicals for combating these insects.

Dean Tran
Charlotte, N.C.

Nurse vs. Machine

Your article "Robo-Nurse" [Headlines] was incredibly offensive and demeaning to nurses. The words "doctor" and "pharmacist" were used equally throughout the story, but you didn't call it "Robo-Doctors." Instead you perpetuated the antiquated view that nurses are not valued members of the health-care system. As a nurse with two bachelor's degrees, a master's and a Ph.D., I doubt a robot could replace me.

Casey Shillam
Via e-mail

Not So Free

In "5 Things to Clean Up for Spring" [How 2.0], you suggest using the "free" service TweakNow.com to

SUMMER MOVIE SPECIAL

Scary Monsters Dissected! Sci-Fi Facts Checked! Multiple Futures Revealed! >>

POPULAR SCIENCE

THE FUTURE NOW

26 Hot Products

5TH ANNUAL

INVENTIONS OF THE YEAR

Meet the Garage Tinkersers behind:

- Armored Snow Blower
- Snowboarder Airbags
- Prime-Armyworm: Mop
- Never-Bare Sunglasses
- Jet-Powered Boogie Boards
- Disease-Detecting Pens
- Bedbug Sniffers
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THIS STORY MARKS POPULAR SCIENCE'S 100TH ANNIVERSARY

U.S. Patent 7,243,001

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scrub uninstalled software. But when I used it, I was led to a site where I was expected to pay \$30. Please don't advertise a product as free when it's not.

Cassandra Fratus
Via e-mail

CORRECTION

An illustration in "Critical Matter" used the wrong element symbol for neodymium. It should have been Nd, not Ne (which is neon).

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MEGAPIXELS

THE MUST-SEE PHOTOS OF THE MONTH

ORDER IN CHAOS

**X-ray astronomy uncovers
a cosmic anomaly**

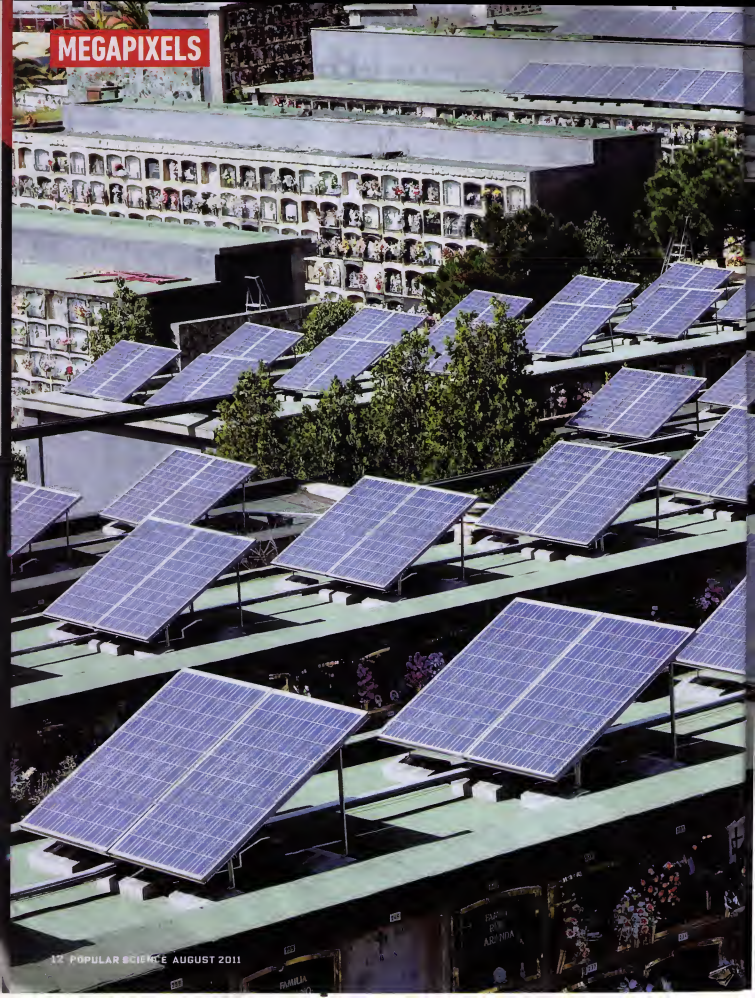
In March, astronomers at Rutgers University studying the supernova remnant Tycho revealed a surprise. Using the Chandra orbiting x-ray telescope, they found unexpectedly structured patterns within Tycho. Normally supernova remnants are chaotic, says Kristoffer Eriksen, who worked on the project. The scientists had anticipated a complicated network of holes and walls inside the royal-blue shock wave, but instead they saw regularly spaced light-blue stripes. The presence of the stripes could be the closest thing to direct evidence that supernova remnants are able to produce cosmic rays, the origins of which are still poorly understood. Eriksen, along with his co-author Jack Hughes, would like to observe Tycho again in a few years to measure how far the stripes move. **BY JENNIE WALTERS**



COURTESY CHANDRA X-RAY OBSERVATORY CENTER



MEGAPIXELS



GRAVE POWER

Mausoleum-mounted solar panels light up a Spanish town

When officials in Santa Coloma de Gramenet, Spain, suggested placing solar panels in the town's cemetery, they were met with significant skepticism. But in 2008, after three years of public outreach, the city council prevailed and the town mounted 462 solar panels on top of a quarter-acre of mausoleums. Santa Coloma is thus far the only town to use alternative power from its cemetery to fill some of the energy needs of its 120,000 residents; the 100 kilowatts is enough to power 60 households. In April, officials from the U.S. Department of Veterans Affairs installed a wind turbine at the Massachusetts National Cemetery, but it will provide power only for the cemetery.

BY JENNIE WALTERS PHOTOGRAPH BY ALBERT GEA

BE ONE WITH IT

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Be one with your tires, and the road will be one with you.
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HANKOOK
driving emotion

WHAT'S NEW

TECH THAT PUTS THE FUTURE IN THE PALM OF YOUR HAND



18

Driver-proof
car safety



20

Running gear for
the long haul



22

Brew your own
beer—fast!

ROCKWELL RK2516K TRANS4MER 2-IN-1 JIGSAW

BLADES: 4-inch T-shank

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PRICE: \$110

GET IT: rockwelltools.com



SHARP ANGLE

A shape-shifting power tool for all your slicing needs

Over the past five years, 12-volt battery-powered tools have been rapidly replacing their corded counterparts. Among these upgrades, the Rockwell Trans4mer merges the portability of a 12-volt with true versatility, combining a jigsaw and a reciprocating saw into one shape-shifting 2.6-pound tool.

Releasing a lever on the main housing frees the blade-

DOUBLE EDGED
Depending on the head angle, the Trans4mer's cutting edge can swivel 180 degrees.

barring arm to move into one of six positions, between zero and 90 degrees. Typical saw motors sit behind the blade and use a transmission to get power to the cutting edge; moving this arrangement could force the motor and transmission out of alignment, causing inefficient power transfer and reducing the strength of the cut. So the Trans4mer's motor

and transmission are located alongside the blade and move with it, allowing the saw to maintain full power in any position, whether downward to make curved cuts like a jigsaw or outward to slice vertically like a reciprocating saw. It can chew through two-inch-thick wood, 1.75-inch-thick aluminum or even 0.2-inch steel. Not bad for 12 volts.—MAX FISCHER

WHAT'S NEW



Char-Be-Gone

Clean your cooker without chemicals. The Grand Grill Daddy brush drizzles water from its handle reservoir, which the grill's heat turns into steam, helping loosen grease and char against the brush's steel bristles. **Grand Grill Daddy Grill Cleaning Brush \$60; williams-sonoma.com**

Tiny Eye

By adding extra reference points to its digital focus system, the Lumix G3 allows photographers to focus on any subject, no matter how small or distant, at a near-pixel level. Tap on the three-inch LCD to magnify an area by four times, then tap again to center the focus where you want. **Panasonic Lumix G3 \$700 (with lens); panasonic.com**



Slice More

Stanley's utility blades stay sharp five times as long as average. The edges are covered with diamond-ground tungsten carbide, to add strength without sacrificing flexibility in the rest of the blade. **Stanley Carbide Utility Blades \$5 for 5; stanleytools.com**



Center Channel

Blast your phone's music library through any surround-sound system. The InCharge Home BT dongle plugs into a receiver's auxiliary port, connects to your device over Bluetooth, and streams your tunes. **XtremeMac InCharge Home BT \$80; www.xtrememac.com**

Virtual Keys

The Lockitron lets you safeguard your house remotely. Connected to a secure router, your lock is controlled with a smartphone, so you can flip it from anywhere. **Lockitron From \$295; lockitron.com**



Piggy Backer

If your iPhone's power runs dry, snap the Third Rail battery pack onto the system's custom case. The lithium-ion cell will fully recharge your handset in as little as an hour. **Third Rail System for iPhone 4 \$90; thirdrailmobility.com**



Top Table

Built around a space-saving 13-inch blade, Bosch's portable table saw has a low center of gravity, making it stable on almost any surface. Its steel base holds the tabletop true without warping, the way plastic models often do. **Bosch GTS1031 10-inch portable table saw \$400; boschtools.com**



THE goods

A dozen great ideas in gear



Smart Stove

Preprogrammed with dozens of cooking sequences and equipped with a food thermometer, this oven can, for example, brown a turkey and then automatically lower the heat for roasting. **Bertazzoni Design Series From \$3,100; us.bertazzoni.com**

Media Streamer

Within its own, closed Wi-Fi network, this 500-gigabyte hard drive can stream stored movies to three devices simultaneously. Its internal battery lasts for five hours on a charge—enough juice to keep the kids occupied on a long car ride. **Seagate GoFlex Satellite \$200; seagate.com**



Water Well

You'll most likely lose the new Klean Kanteen before it wears out. The stainless-steel bottle and cap are free of paint or plastic, which can rub off, chip, or break. **Klean Kanteen Reflect \$33; kleankanteen.com**



Long-Lived

On one set of AAs, HP's wireless mouse squeezes out twice the battery life of other mice. It communicates with your PC over Wi-Fi, which uses far less power to transmit location data than the mouse-standard Bluetooth. **HP WiFi Mobile Mouse \$50; hp.com**

Better Battle

A new take on Battleship uses infrared to bring random elements to gameplay. The game's eye tracks players' fleets and hits them with events such as typhoons and spy-plane flyovers. **Battleship LIVE \$50; hasbro.com**



WHAT'S NEW COMING SOON

EYES ON THE ROAD



Two new sensor-based safety systems lead toward the crash-proof car

The idea of a robot assuming control of your car takes some getting used to. But the race to build increasingly autonomous automotive safety systems is well under way, as the cost of cameras and sensors drops and engineers get better at programming those tools to work together.

A big advance arrives this fall with the 2012 Mercedes-Benz CL-class. Its Spotlight safety system will link night-vision cameras with video-driven adaptive high beams to find people in the car's path and warn both driver and pedestrian. An onboard computer continuously scans images captured by the car's windshield-mounted night-vision camera, looking for human shapes. If it finds one, the headlights point at the person and flash. Joerg Breuer, the manager for Active Safety Systems at Mercedes, says Spotlight detects pedestrians 1.3 seconds earlier than a driver can.

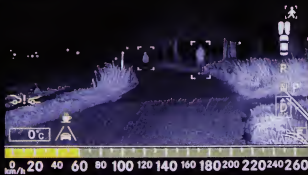
▼ ROBO SENSE

If Mercedes's pedestrian-detecting Spotlight system detects an oncoming car, it will refrain from flashing its brights, lest it make things worse by blinding the driver of the oncoming car.

Laser scanners will make sensor-driven safety systems more accurate still. Take BMW's Left Turn Assist, which the company revealed earlier this year but hasn't yet slated for production. Left Turn Assist uses a trio of laser scanners, along with a lane-detecting video camera and GPS, to make left turns—statistically one of the most dangerous maneuvers on the road—safer. When a computer senses that the driver is about to take a left, lasers scan a 200-degree field for hazards. If the system detects an imminent threat, and the car is moving slower than 6

mph, it will brake automatically. At higher speeds, it triggers audio and visual alarms. Laser scanners are still prohibitively expensive, says Dirk Wisselman, BMW's head of Advanced Safety Systems, but the cost is falling quickly.

Wisselman sees Left Turn Assist as only a first step. The real change, he says, will come from car-to-car communication, in which vehicles can detect one another and share information about speed and trajectory. "This has tremendous implications for safety," Wisselman says. "And I think we'll see it in the next decade." —JOSH DEAN



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WHAT'S NEW FULLY LOADED

MARATHON TOOL KIT

Gear to help long-distance runners get into shape

Training to run 26.2 miles is never easy. It takes time, energy and—if you're smart—a few well-chosen pieces of gear.

—BRETT ZIMMERMAN

Socks

To reduce the skin-on-fabric friction that causes most blisters, Drymax combined its anti-sweat fibers with polytetrafluoroethylene, the coating on nonstick pans. Even in a down-pour, the socks can help prevent painful rubbing.

Drymax Triathlete Socks \$16;
drymaxsports.com

Water Source

Specifically designed for marathoners, this 12.7-ounce CamelBak vest holds a two-liter hydration pouch with an extra large opening for quick refilling. Runners can tighten straps along the reservoir to help it empty to stop sloshing and increase flow. Two adjustable sternum belts ensure a perfect, non-chafing fit. **CamelBak Marathoner Vest \$100;** camelbak.com

Shoes

Altra's The Knit shoes combine the benefits of barefoot running with the support and shock absorption of sneakers. The running sole is thicker at the heel, so the heel strikes the ground without putting pressure on the knees. They have an even sole so runners run more like they would without shoes, landing the foot flat on the ground and slightly bent. **The Knit; \$120;** altrarunning.com

Headphones

These rain- and sweat-proof Bluetooth earbuds tame boredom on long training runs. In addition to acting as a wireless headset for phone calls, they can stream music from a smartphone or iPod Touch, or from their built-in FM radio. **Jabra SPORT \$100;** jabra.com

Watch

With Nike's GPS watch, runners can track their location, pace and elevation—and compete with friends around the world. The watch links to Nike's four-million-strong runners' network so you can share stats and routes. **Nike+ SportWatch GPS \$200;** nikerunning.com



HSO 200 / F8, 1/250s | Photo by Kayce M. Baker

THE CAMERA: REDEFINED

Fujifilm has engineered a lens and imaging sensor combination designed to deliver unsurpassed image quality. The FinePix X100 provides smooth tonal rendering, an exceptionally low S/N ratio and outstanding image clarity. With advanced imaging technology encased in a sleek retro-styled design, the FinePix X100 reinvents photographic inspiration while redefining what a camera can be.



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BETTER BEER FASTER

A personal brewery that spouts pro-quality suds in a week

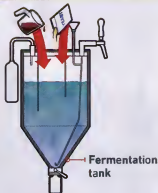
Most beer drinkers don't have the time (or inclination) to muddle through the painstaking home-brewing process, but the WilliamsWarn Personal Brewery simplifies just about everything. The brewing system produces pro-grade beer in seven days, instead of four weeks. For now, WilliamsWarn brewers are limited to light ales, but eventually, says inventor and master brewer Ian Williams, they'll be able to make, store, and pour 50-pint batches of beer, from lagers to stouts.

The machine saves time by combining home brewing's longest steps—fermentation, which usually takes a week, and carbonation, which can take at least two. The fermentation tank is also a pressure vessel, which traps carbon dioxide released by yeast, force-carbonating the beer. The system also does away with two common foes of freshness: The sealed vessel keeps out oxygen, a culprit behind flat-tasting pints, and a valve at the bottom of the tank isolates the yeast from the beer as soon as fermenting is done, which prevents meaty, off flavors. —MARTHA HARBISON



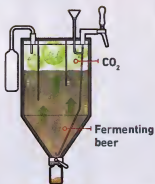
GET IT:
WilliamsWarn Personal Brewery
\$5,000 (U.S. availability pending);
williamswarn.com

HOW TO BREW IN SEVEN DAYS



Day 1: Brew

Add water, malt extract and yeast to the fermentation tank, and seal the top. Set the thermostat to 70°F, the temperature at which ale yeasts ferment sugars most quickly while reducing nasty flavors, such as overly buttery diacetyl.



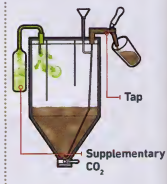
Days 2-5: Ferment and Carbonate

When yeast turns malt sugars into ethanol, one by-product is carbon dioxide. The gas is trapped in the tank, and as the pressure builds, CO₂ is forced into the beer. A valve allows brewers to regulate the amount of carbonation.



Day 6: Clarify

Once the beer is chilled to 42°F, brewers add a clarifying agent, which causes the yeast to drop into a collection jar at the base of the tank. Once the beer is clarified, brewers simply close the tank's lower valve, detach the jar, and dump the yeast down the sink.



Day 7: Drink!

The CO₂ captured in the tank forces the beer through a tube to the tap. A supplementary CO₂ canister maintains internal pressure as the beer level drops.

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SMART BROWSERS

Computers with Google's OS do all you need with little more than the Web

THE TREND

Computers, or "Chromebooks," that do almost everything through a Web browser, from playing *Angry Birds* to automatically backing up your documents

WHY NOW

The proliferation of HTML5 and advances in Java Web coding have led to full-featured applications that can run within Web browsers. Users can play media or videogames or edit presentations without installing or running any additional programs. Meanwhile, mobile-broadband networks continue to expand, allowing laptops full connectivity nearly anywhere—a must for Web-reliant Chromebooks.

HOW YOU'LL BENEFIT

Because the Chrome OS uses only a Web browser and media player, it requires less power than Windows or Mac OS X, both of which need to run several programs at once to function. Batteries last up to 8.5 hours, and machines start up in as little as eight seconds. What's more, Chrome saves all your Google data into its cloud, which is accessible from any Chrome-based computer. No matter what Chromebook you use, it will always appear like your own machine.—STEVE MORGENSTERN

SPEC CHECK
Chromebooks run dual-core 1.66-gigahertz Intel processors and have 16 gigabytes of storage.

Xi3 ChromiumPC

Xi3's four-inch CPU is a Chrome desktop that connects to any monitor and keyboard. With it, users can easily shift between their home and work computers, since both will link to the same data. Price not set; xi3.org

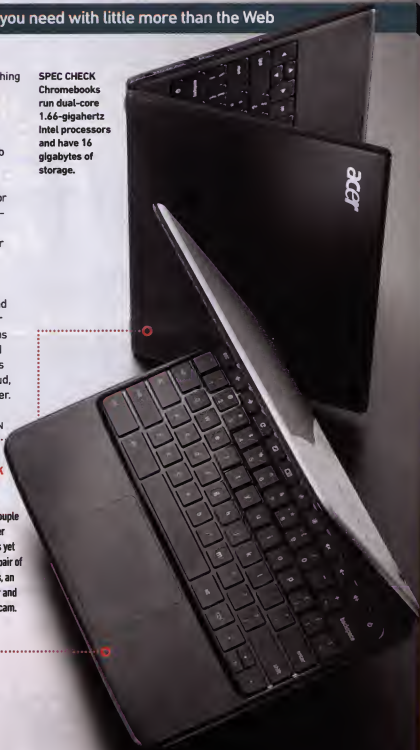
Samsung Series 5

In addition to two gigs of RAM and optional 3G, Samsung's screen is a third brighter than average, so it shows colors more clearly outdoors.

From \$430; samsung.com

Acer Chromebook

At 3.2 pounds, Acer's Chrome notebook is a couple of ounces lighter than Samsung's yet still packs in a pair of stereo speakers, an HDMI connector and a high-def webcam. From \$350; acer.com



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SECURITY

SPY VS. SPY

Casinos are filled with hidden cameras. Too bad they can't see the ones hiding up gamblers' sleeves

In January, at the newly opened \$4-billion Cosmopolitan casino in Las Vegas, a gang called the Cutters cheated at baccarat. Before play began, the dealer offered one member of the group a stack of eight decks of cards for a pre-game cut. The player probably rubbed the stack for good luck, at the same instant riffling some of the corners of the cards underneath with his index finger. A small camera, hidden under his forearm, recorded the order. After a few hands, the Cutter left the floor and entered a bathroom stall, where he most likely passed the camera to a confederate in an adjoining stall. The runner carried the camera to a gaming analyst in a nearby hotel room, where the analyst transferred the video to a computer, watching it in slow motion to determine the order of the cards. Not quite half an hour had passed since the cut. Baccarat play averages less than six cards a minute, so there were still at least 160 cards left to play through. Back at the table, other members of the gang were delaying the action, glancing at their cellphones and waiting for the analyst to send them the card order.

The gang had just walked away from Macau, the largest gambling city on Earth, with millions. They



THE BIG STEAL
Security systems at casinos such as the Cosmopolitan in Las Vegas track data ranging from what their patrons are eating to how much they are betting on each hand. Cheaters are also increasingly using technology, hiding cameras up sleeves and in betting chips.



took \$100,000 from the Bicycle Casino in Los Angeles only weeks after the Las Vegas run. The Cutters' scam did not require marking or switching cards, so casinos' card scans and tracking software was irrelevant. Security consultants say that the gang numbers about 70. (With so many players, facial

analytic software is easy to beat.)

At the Cosmopolitan, about 25 black-domed surveillance cameras hang from the ceiling above the high-stakes baccarat tables. Camera feeds, card scans, information about individual betting chips, and even biometrics about players are fed to a security suite at most new casinos, where software analyzes the data to determine betting outcomes in real time. A Cosmopolitan security official hovered a few feet behind the players, too, tracking wins, losses and betting patterns to identify cheats like the Cutters. Jeff Voyles, a hotel management instructor at the University of Nevada at Las Vegas, says that a new casino will spend at least \$10 million on its surveillance.

Even so, casinos lose 6 to 8 percent of their revenue every

TO CATCH A THIEF

How casinos spot cheats.
And how cheats beat the system

TAGGED CHIPS Assigning a unique radio-frequency identification (RFID) serial number to each betting chip eliminates counterfeiting, and stolen chips can be deactivated. The company Gaming Protection International uses RFID sensors and electronic tags loaded with information, such as the cash amount of the chip, so casino security can track how much money is on the table. Casino de Genting in Malaysia uses RFID-enabled baccarat tables to prevent cheaters from slipping more chips onto the table after a win.

FACE TIME Casinos use facial-recognition software to match video recordings of patrons with a database of known cheaters. But backlighting, head movement, and hats and sunglasses are enough to stymie the matching process. In June, Biometrica, which has sold facial-recognition software to up to 175 casinos, introduced a system that takes nine photos of a gambler's face from different angles in areas where the lighting is consistent—on escalators, in turnstiles, or standing in front of ATMs—and compiles the shots for a clearer picture.

THE TROJAN HORSE In 2009, a hacker was caught after he installed a program that took over the credit meter on a slot machine. After deliberately jamming the machine by sticking his finger in the payment slot, he called a casino tech to fix it. With the machine open, the hacker peered inside to locate the input-output slot on its computer. Once the tech left, the hacker deftly inserted a wire into the slot through a gap between the lower and upper doors of the machine. He then plugged in a chip with a program that gave him 50 credits every time he punched a button connected to the chip.


year to some form of cheating, and sophisticated hustlers can take as much as \$500,000 in just an hour. As cameras get better, smaller and cheaper, the cheaters are gaining an edge and casinos are struggling to keep up. "We're really buried in tech and don't know how to get out," Voyles says, adding that because security systems don't generate

income, casinos are slow to update.

But that night at the Cosmopolitan, the house won. One of the Cutters slipped up, and security was alerted. Nevada Gaming Board agents were called in and shut down the game and detained the players. Still, they couldn't find a camera. Bill Zender, a security contractor for high-end casinos, says that the

agents didn't find anything because they couldn't get a warrant to search the gamblers. Video footage showed no illegal moves or suspicious behavior, and under Nevada law, the agents didn't have probable cause to perform a full body search. The Cutters were released.

In May, some of the Cutters were finally caught. A casino surveillance



SMART SHOE In 2009, a Japanese card manufacturer introduced a device called Angel Eye that uses a scanner hidden in the shoe, the plastic card case dealers use, to track unique codes on each card. Dealers scan when they deal and rescan at the end of each hand. If a cheater swaps in a card that's different than the one he was dealt, a computer linked to the shoe detects the discrepancy.

TABLE EYE Overhead cameras send images back to the surveillance suite, where character-recognition software reads the cards. The casino's surveillance team can then follow each hand and spot switches and false shuffles. For blackjack, the software can instantly compare actual game outcomes with what would have happened if every player made the smartest decisions with the cards they were dealt. Cheats leave a trail of improbably lucky wins.

THE CUT In baccarat, the dealer presents a player with a card to cut the deck before play. Using the cut card, the cheater shields his index finger from view while he brushes the edge of the deck. A camera on his sleeve records the card order. The player leaves the table and passes the camera to an accomplice. The video is slowed down, the card order determined, and the results sent to confederates back at the table.

**SOPHISTICATED
HUSTLERS CAN
STEAL AS MUCH AS
\$500,000 IN AN HOUR.**

manager in the Philippines spotted a "spatula-like" camera hidden up a baccarat player's sleeve and he identified four more likely gang members nearby. Meanwhile, casinos are considering installing counter-surveillance scanners that detect the low-frequency sound that video cameras emit.

Not four miles from the

Cosmopolitan, you can buy such a scanner for \$720 from Fox's Spy Outlet. Manager Andrew Rowles will tell you that it has a range of only a few feet, and it might be picking up a cellphone, not a video camera. Rowles can also sell you a camera to beat the scanner. It's hidden in a stick of gum and costs just \$150.

—ANDREW ROSENBLUM

THE OIL DRILL AT THE END OF THE EARTH

The longest, deepest wells—plus reindeer

On Sakhalin Island, in Russia's far east, temperatures can fall to 35 degrees below zero. Many islanders herd reindeer. And in January, oil crews drilled the world's longest and deepest extended-reach well, 7.7 miles down into the ground and 7.1 miles out under the ocean. Seven of the 10 longest oil wells on Earth have been drilled there since Exxon Mobil launched its Sakhalin-1 project in 2003. Crews expect to keep breaking their previous records in the coming months.

The seven-story oil rig at Sakhalin, nicknamed Yastreb (the Hawk), is the industry's most powerful, with four 7,500-psi mud pumps, 14,000 barrels of liquid-mud storage and six generators. It has two walls to help it withstand the cold and earthquakes, which are frequent. The Yastreb's drill torque is approximately 91,000

foot-pounds (a pickup truck operates with about 200).

Extended-reach drills travel both outward and down. To control the position and angle of the wellbore, drilling engineers use magnetometers and inclinometers; the information the tools gather is sent back by pressure pulses in the drilling fluid, which the engineers then analyze at the surface. The team—about 800, mostly Russians—pre-maps each expedition using 3-D seismic imagery to create visual models of the conditions in the rock and the locations of the oil reservoir. They can reach their target with an accuracy of just a few feet. It's as if they were standing in the middle of Central Park and drilled down to a specific doorway of the New York Stock Exchange.

—NOREEN MALONE

BIG EMPTY Crews working Sakhalin's seven-story rig aim to have drilled 40 to 50 new wells by 2013. Future drilling expeditions could reach more than 9.2 miles off the coast.



DOWN AND OUT Extended-reach drills first push straight down while the motor rotates counterclockwise. Crews apply torque at an increasingly flat angle until the drill bit is horizontal and begins to push outward.

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HULL ATTACK

Barnacles destroy boats, but getting rid of them destroys the sea—until now

THE PROBLEM: Biofouling, which occurs when barnacles (or any other clinging species) cover a ship's hull or anchor line. The U.S. Naval Academy estimates that biofouling creates enough hull-drag to increase the Navy's petroleum bill by about \$250 million every year. For millennia, copper has been used to keep marine life at bay: the Greeks and Romans used copper nails for this reason. The Navy uses it too, mixing powdered copper into boat paint. But as the paint wears, copper seeps into the water, where it has been shown to harm salmon and oysters. And as the paint thins, the barnacles return.

THE SOLUTION: Medetomidine, a chemical that activates the octopamine receptors (similar to adrenaline receptors) in barnacle larvae, causing them to flee. Barnacle larvae are free-floating and harden only after they have attached to a surface. Researchers at the University of Gothenburg in Sweden mixed small Plexiglas capsules filled with medetomidine into boat paint, young barnacles were scared away, and the hulls remained pristine.

At high levels, medetomidine can lighten the color of fish scales, making them more vulnerable to predators. But the capsules ensure that the chemical is released slowly, so it lasts longer and minimizes environmental damage.—JOSHUA SAUL



BEFORE Thriving barnacles make boats less efficient.



AFTER Even post-treatment, corrosion can sink ships.

FROM LEFT: BRANDON COLE/GETTY IMAGES; GETTY IMAGES; TIM LAMAN/GETTY IMAGES

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ROLL AND TUMBLE
When a charge heats and curls a wire, the four-inch GoqBot contracts and rolls about a foot per second.

THE SCALE

The longest measured moment, the lifetime of the universe itself, is 10^{24} times as great as the shortest—a breadth made visible only by way of logarithmic compression.

1 Electron jump

After an electron is struck with ultraviolet light, the delay before it leaps from its orbit—the shortest event ever measured—is **20 attoseconds**.

Neural signal

Neurotransmitter molecules hop from one neuron to the next in about **50 microseconds**.

Blink of an eye

A human eyelid closing and opening takes **0.3 seconds**.

Sunbeams

Light travels from the sun to the Earth in **8.2 minutes**.

Virus survival

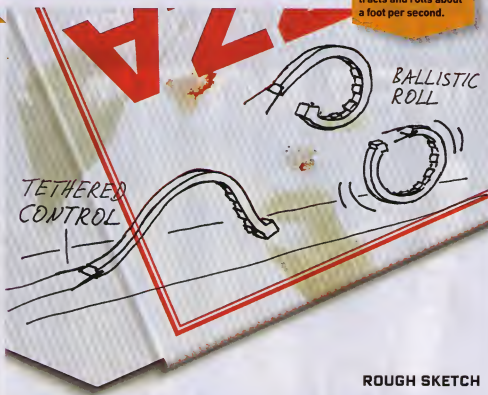
The hepatitis B virus can live outside the human body and remain infectious for at least **one week**.

Earth's age

Our solar system has been around for **4.6 billion years**.

Universe's age

The cosmos has existed for **13.8 billion years**.



ROUGH SKETCH

CREEPY CRAWLY

Building a fleshy robot caterpillar

I make robots that are soft and floppy. If you can change your shape, you can go anywhere—you can squeeze through small holes in the rubble field and navigate unstructured terrain like forests. The problem is that if you're soft, you're slow, because when you push against something, your body deforms rather than creating forward motion. So we looked to the caterpillar as a model.

Caterpillars have an interesting technique for moving quickly and powerfully: They contract their belly muscles, curl up, and become wheels. They can roll several body lengths within 100 milliseconds. We said, Let's see if we could do that with a robot. Our GoqBot can inch around like a caterpillar, but it also has a coiled shape-memory-alloy wire running through it that

shrinks in length when it's heated. We warm it up through a tethered control, the wire shortens, the robot curls, and it rolls away quickly. Right now, the wire is our muscle. But the second stage—and we're working on this now—is developing technology to grow robots out of organic materials. We want to find a way to grow insect muscles inside a robotic device and to fuel the muscles with sugar and fat.

Once you can build and control something that is soft and floppy, you could build robots that are environmentally friendly. Imagine a robot that you could potentially eat or set aside to decompose when you're done with it.

—BARRY TRIMMER, as told to Flora Lichtman. Trimmer, a neurobiologist at Tufts University, is now upgrading the GoqBot so that it can climb.

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Scientifically Engineered to Defy Pain, Defy Aging & Defy Fatigue

This is my story

I used to be more active. I used to run, play basketball, tennis, football... I was more than a weekend warrior. I woke up every day filled with life! But now, in my late 30's, I spend most of my day in the office or sacked out in front of the TV. I rarely get to the gym—not that I don't like working out, it's the nagging pain in my knees and ankles. Low energy and laziness has got me down. My energy has fizzled and I'm embarrassed to admit that I've grown a spare tire (I'm sure it's hurting my love life). Nowadays I rarely walk. For some reason it's just harder now. Gravity has done a job on me.

Wear them and you'll know

That's what my doctor recommended. He said, "Gravity Defyer shoes are pain-relieving shoes." He promised they would change my life—like they were a fountain of youth. "They ease the force of gravity, relieving stress on your heels, ankles, knees and back. They boost your energy by propelling you forward." The longer

he talked, the more sense it made. He was even wearing a pair himself!

Excitement swept through my body like a drug

I received my package from GravityDefyer.com and rushed to tear it open like a kid at Christmas. Inside I found the most amazing shoes I had ever seen—different than most running shoes. Sturdy construction. Cool colors. Nice lines...

I was holding a miracle of technology. This was the real thing.

GDefy Benefits

- Relieve pain
- Ease joint & spinal pressure
- Reduce fatigue & tiredness
- Be more active
- Have more energy
- Appear taller
- Jump higher, walk and run faster
- Have instant comfort
- Cool your feet & reduce foot odor
- Elevate your performance

I put them on and all I could say was, "WOW!" In minutes I was out the door. I was invincible; tireless in my new Gravity Defyer shoes. It was as if my legs had been replaced with super-powered bionics. What the doctor promised was all correct. No more knee pain. I started to lose weight. At last, I was pain free and filled with energy! I was back in the game. Gravity had no power over me!

Nothing to lose: 30 Day Free Trial*

So, my friend, get back on your feet like I did. Try Gravity Defyer for yourself. You have nothing to lose but your pain.

Tell us your story! Login at GravityDefyer.com and share your experience.

Customer Satisfaction Speaks for Itself!

4 out of 5 customers purchase a 2nd pair within 3 months.



ABSORB SHOCK
Eliminate pain from every step.



REBOUND PROPELS YOU FORWARD
Reduce fatigue. Be more active

a \$129.95 value

MEN (Shown above)

TB902MWBs

sizes 7-13

Med/Wide and Extra/Wide Widths

WOMEN (Silver with Navy)

TB902FWBs

sizes 5-11



EXCLUSIVE ONLINE OFFER

FREE 30 DAY RISK-FREE trial*. Not available in stores.

Visit ShoesOnSteroids.com/MC9HC88

or take advantage of this exclusive offer by phone, and dial (800) 429-0039 and mention the promotional code below.

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▲ **MARCH 2004** While working as the scientific adviser on movies such as *Mutk*, *Aeon Flux* and *I Am Legend*, John Underkoffler was refining his first real gestural-recognition interfaces. Today he has left film to focus on his inventions full-time.

HAND COMMAND

Building a gesture-driven digital interface

John Underkoffler looks at his desktop computer and sees an outmoded, inadequate tool. Trackpads and touchscreens, the former MIT instructor says, are limiting. Don't even get him started on the mouse. The future, he says, is in gesture-recognition-based interfaces, which he calls "spatial operating environments," or SOEs.

Underkoffler has already introduced millions to his vision of a working SOE. Remember the scene where Tom Cruise pieces together a crime, gesticulating wildly in front of interactive screens in *Minority Report*? That was Underkoffler's idea. Now he's building and selling working

▲ **POINT, PUSH, PULL** Using a platform called G-Speak, Underkoffler manipulates objects with his hand motions, similar to Tom Cruise in *Minority Report*.



models of his Hollywood version. "This is what the future has to be," he says. "Otherwise we're going to end up as little mouse-clutching gnomes, tethered to our desktops."

In an SOE, cameras and infrared sensor strips lining the ceiling read hand gestures and translate them into commands. Point your finger like a gun at a screen, for instance, and the object on the screen sticks with it. The SOE in *Minority Report* was rendered in such convincing detail that it's still referenced as a model. Two years after the movie premiered, Underkoffler co-founded Oblong Industries. He now serves as its chief scientist and constructs customized SOEs for such clients

as Boeing and Aramco. His latest invention is an SOE capable of recognizing finger movements of less than a tenth of a millimeter, so hand commands are much subtler than Tom Cruise's (since nobody wants to wave his hands around throughout the workday). Installation costs about \$200,000.

Underkoffler's end goal is nothing short of a universal gesture-based language that will allow us to communicate with our ever-growing number of smart devices across multiple platforms. "The world we're building," he says, "is one where you can walk up to any screen, anywhere in the world, point to it, and take control."—STEVE DALY

BIG SCIENCE!

To improve our view of a vast and complex universe, scientists are creating increasingly ambitious new tools. The work is not easy. Truly big science requires decades of expensive commitment from multiple nations. But the instruments that result are nearly as awe-inspiring as the new worlds they help us discover. We rank the 10 most epic among them.

ON TRACK This 2.4-mile-long ring is part of the Relativistic Heavy Ion Collider (#10 on our list).

An aerial photograph of a university campus, showing a mix of green spaces, trees, and various buildings. A prominent red rectangular box is overlaid in the upper right corner, containing white text. The campus features a large central building complex, several smaller structures, and a prominent white spherical building on the right side. The surrounding area includes parking lots, roads, and more greenery.

HOW WE DID IT

Like anything that's large and involved, big science is not easy to measure. For our rankings, we took into account four objective factors: the construction costs above all, but also the operating budget, the size of the staff and the physical size of the project itself. Even these were hard to compare on an apples-to-apples basis, though, so we also used a tiering system. Then we added in three subjective factors, weighing them more heavily to reflect their relative importance: the project's scientific utility, its utility to the average person ("what will it do for me") and the always essential "wow" factor. For a complete explanation of our scoring, visit popsci.com/bigscience.

RELATIVISTIC HEAVY ION COLLIDER

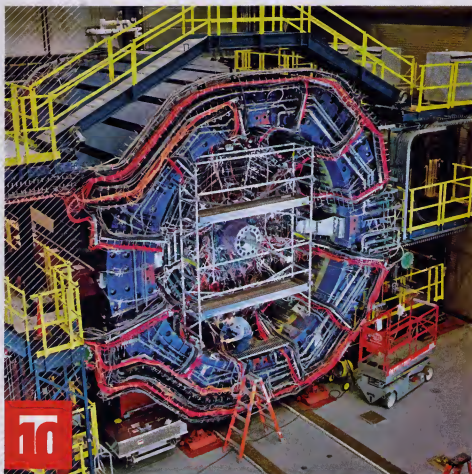
A TIME MACHINE TO REVEAL THE ORIGINS OF THE UNIVERSE

When gold ions speeding inside the Relativistic Heavy Ion Collider on Long Island, New York, smash into each other, these collisions can produce temperatures of up to 7.2 trillion degrees Fahrenheit, so hot that protons and neutrons melt. As those particles disintegrate, the quarks and gluons of which they are comprised freely interact to form a new state of matter, called a quark-gluon plasma. As the material cools after the collision is over, protons and neutrons reform, producing 4,000 subatomic particles in the process. Using the RHIC, scientists are trying to re-create the conditions that existed during the first millionth of a second after the big bang.

SCIENTIFIC UTILITY: To better understand how matter has evolved in our universe, physicists at the RHIC send gold atoms through several accelerators, stripping away their electrons so they become positively charged ions. Those ions launch into two circular tubes and race at up to 99.9 percent of the speed of light before they collide. In examining the remnants of these collisions, the scientists have found that particles at this post-big-bang stage behave more like a liquid instead of the predicted gas.

WHAT'S IN IT FOR YOU: RHIC scientists are currently developing devices that accelerate protons and more precisely guide them to irradiate and kill cancerous tumors in humans. Engineers have also used the heavy ion beam to punch tiny holes in plastic sheets, making filters that can sort substances at the molecular level. Down the line, we might see more-efficient energy-storage devices based on the superconducting magnet technology used in the RHIC.

—GREGORY MONE

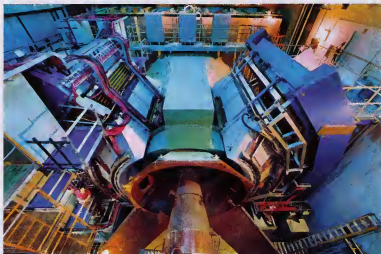


Annual budget: \$160,000,000
Construction cost: \$671,000,000
Staff: 700
Physical size: 2.4-mile circumference
Scientific utility: 6*
What's in it for you: 2*
Wow factor: 4*

*on a scale of 1 to 10

▲ **PLASMA SENSOR** The RHIC's STAR detector will collect data on quark-gluon plasmas.

▼ **PARTICLE TRACKER** The PHENIX detector records the tracks of particles such as photons and muons.



NEPTUNE

THE WORLD'S LARGEST UNDERSEA OBSERVATORY

Oceans cover nearly three quarters of the Earth's surface and contain 90 percent of its life, yet they are almost entirely unexplored. Neptune, an ocean-observatory network that consists of some 530 miles of cable and 130 instruments with 400 sensors, all of it connected to the Internet, will provide the first large-scale, around-the-clock monitoring of an ocean system, including animal life, geology and chemistry.

SCIENTIFIC UTILITY: Neptune's battery of instruments, which lie as far as 220 miles off the coast of British Columbia on the Juan de Fuca tectonic plate, offer a real-time view of the area. A tethered float, outfitted with radiometers, fluorometers and conductivity sensors, ferries up and down the 1,300-foot water column from the seabed to the surface, sampling the column's chemical and physical conditions to determine how it changes over time. A remotely operated vehicle called ROPOS installs instruments and gathers data. Its high-definition camera

provides still photographs and video of animals and their behaviors, which scientists could use to gauge changes in the local ecosystem. Hydrophones positioned on the seafloor record dolphins and whales to track their numbers and migration routes. And a remotely operated crawler named Wally drives over the seabed to monitor underwater methane deposits, which could exacerbate global climate change and also be a potential source of energy.

WHAT'S IN IT FOR YOU: Armchair (and professional) scientists worldwide can tune in over the Internet to see streaming video of Wally the crawler rolling over the seafloor, watch deep-sea tubeworms waving in the currents of a hydrothermal vent, or listen to a humpback-whale song.—BROOKE BOREL

Annual budget:
\$12,000,000
Construction cost:
\$106,000,000
Staff: 45
Physical size:
530 miles of cables
Scientific utility: 8
WIIFY: 4
Wow factor: 8



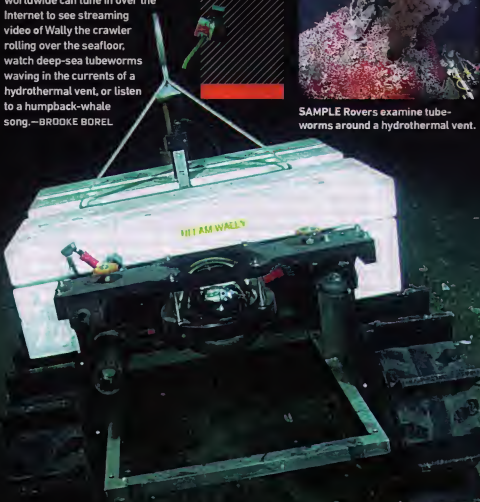
PLACE The ship *Ile de Sein* carried Neptune parts to sea.



TEST The Vertical Profiler analyzes conditions in the water column.



SAMPLE Rovers examine tube-worms around a hydrothermal vent.



CRAWL Wally will examine the seafloor 2,800 feet below the surface in the Pacific Ocean.



VERY LARGE ARRAY

THE RADIO TELESCOPES THAT LISTEN TO THE COSMOS



Annual budget: \$15,000,000
Construction cost: \$300,000,000
Staff: 280
Physical size: 27 antennas on 39 miles of track
Scientific utility: 8
WIIFY: 3
Wow factor: 6

Positioned on hundreds of square miles of desert outside Magdalena, New Mexico, the Very Large Array (VLA) is one of the largest telescopes in the world. Its 27 individual radio antennas, each of which is 82 feet in diameter, form a Y with arms 13 miles long and gather signals from some of the brightest objects in the universe. Its sister project, the Very Long Baseline Array (VLBA), is a line of 10 radio antennas that extends 5,531 miles from Hawaii to the Virgin Islands. The VLA and VLBA create detailed images of celestial objects as close as the moon and as far away as the edge of the observable universe.

SCIENTIFIC UTILITY: Because radio waves can penetrate the cosmic dust that obscures many objects, the VLA and VLBA can see things that optical telescopes can't. Using the VLA, scientists have studied the black hole at the center of the Milky Way, searched for the origins

of gamma-ray bursts in faraway nebulae and, in 1989, received radio transmissions from the Voyager 2 satellite as it passed Neptune, giving us the first up-close photos of the gas giant and its moons. The VLBA measures shifts in the Earth's orientation in the universe. By focusing on distant, virtually fixed objects—such as quasars—over time, scientists can detect any apparent changes in Earth's orientation in space. This orientation can be thrown slightly out of place during major earthquakes, like the one that struck Japan earlier this year.

WHAT'S IN IT FOR YOU: Pick a chapter in a modern astronomy textbook, and you will find some material or theory based on data collected by the VLA and VLBA. The VLBA also gathers data on the paths of near-Earth asteroids, which could help scientists predict if one is on a collision course with our planet.—B.B.

NATIONAL IGNITION FACILITY

A GIANT LASER FUSION EXPERIMENT

Considered the world's largest and most energetic laser, the National Ignition Facility, located in Livermore, California, stretches the length of three football fields, stands 10 stories tall, and generates two million joules of ultraviolet energy. That blast can cause the laser's target to reach temperatures of more than 100 million degrees and pressures of more than 100 billion times the Earth's atmosphere—similar to conditions found in the cores of stars and gas-giant planets.

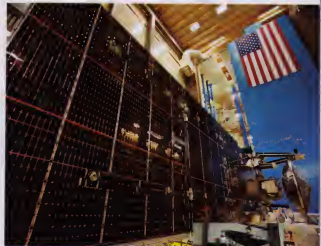
SCIENTIFIC UTILITY: When the 192 individual beams that make up the NIF laser converge on a target that contains atoms of deuterium

MOBILE NETWORK

The VLA's radio antennas sit on tracks so scientists can change the array's configuration.



Annual budget:
\$30,000,000
Construction cost:
\$928,000,000
Staff:
Hundreds
Physical size:
66 feet in diameter, 15 feet tall
Scientific utility: 7
WIIFY: 1
Wow factor: 10



JUNO

A JUPITER ORBITER ON A SUICIDE MISSION



Just before *Juno* enters Jupiter's orbit in 2016, the spacecraft, pulled by the gas giant's tremendous gravity, will reach speeds of 134,000 miles an hour, making it one of the fastest human-made objects ever built. Once in orbit, the craft will make 33 passes around the planet and then dive directly into it. On its suicide run, it will plow through Jupiter's hydrogen atmosphere until it burns up like a meteor.

SCIENTIFIC UTILITY:

While *Juno* circles Jupiter, a suite of nine instruments will study the planet's many layers. Jupiter was the first planet in the solar system to form, and because it is so large, its gravity has retained original material found in the early solar system, primarily hydrogen and helium. This

characteristic makes the planet a valuable window into the solar system's origins. Measurements of Jupiter's magnetic field could finally resolve the debate over whether the planet has a rocky core. *Juno*'s magnetometers will characterize the depth and motions of the metallic hydrogen ocean found in the interior, which generates the strongest magnetic field in our solar system aside from that found around the sun. Finally, a microwave radiometer will measure the amount of water in Jupiter's deep atmosphere, a key to understanding how the planet was originally formed.

WHAT'S IN IT FOR YOU:

Study of Jupiter's complex weather patterns could help us predict our own, but for the most part this is pure scientific research.

—JENNIFER ABBASI

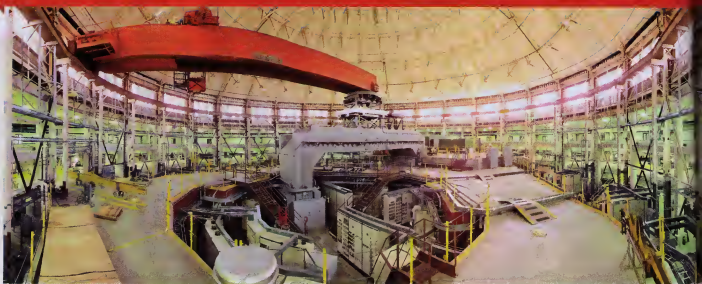


Annual budget:
\$140,000,000
Construction cost:
\$3,540,000,000
Staff: 1,000
Physical size:
172,800 square feet
Scientific utility: 4
WIIFY: 2
Wow factor: 8

(hydrogen with one neutron) and tritium (hydrogen with two neutrons), the atoms' nuclei fuse and create a burst of energy. NIF scientists are trying to refine this process to produce, for the first time, a net energy gain from fusion reactions. They are also using their research to study what happens to nuclear weapons over time, a crucial question when judging the safety and reliability of the U.S. stockpile. Finally, because conditions in the laser's target mimic those in the cores of massive stars, scientists hope to understand how fusion produced some of the heavy atomic elements, such as gold and uranium.

WHAT'S IN IT FOR YOU: If you happen to be storing nuclear weapons in your home, NIF data could help you determine whether your stockpile is reliable. Otherwise, some NIF proponents say that it could provide fusion power—although a fusion power plant probably won't be based on giant lasers.—KATHERINE BAGLEY





DOME OF LIGHT Above, the booster synchrotron ring at the ALS. Below, the storage ring and the individual experiment beamlines



ADVANCED LIGHT SOURCE

THE ULTIMATE MICROSCOPE

Annual budget:
\$54,200,000
Construction cost:
\$154,000,000
Staff: 223
Physical size:
78,432 square feet
Scientific utility: 10
WIIFY: 10
Wow factor: 2

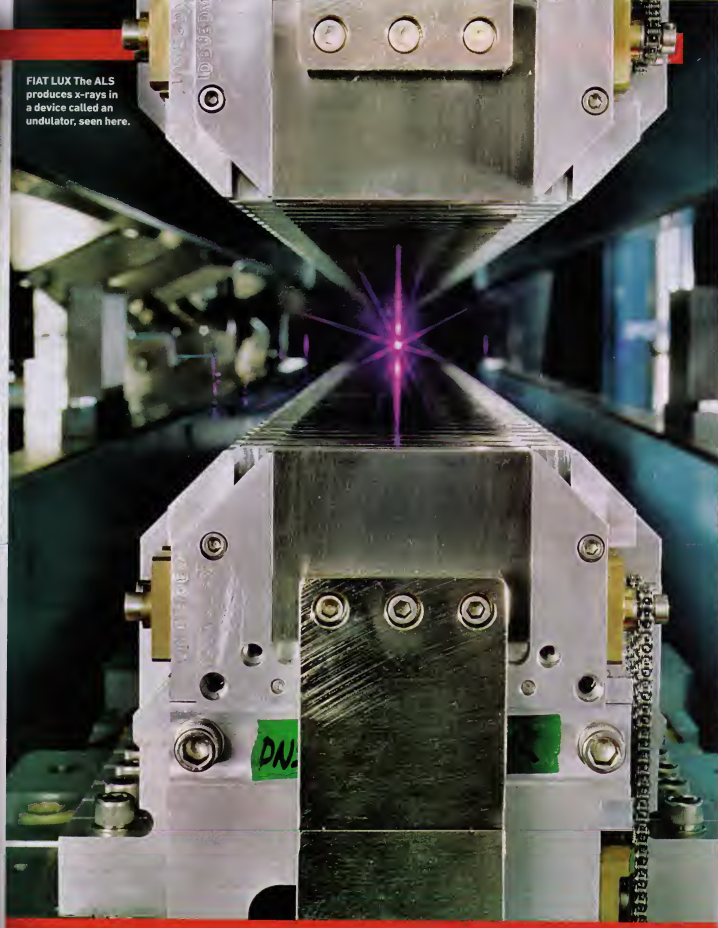
Since 1993, researchers at the Advanced Light Source, a particle accelerator in Berkeley, California, have been sending a photon beam a million times as bright as the sun's surface into proteins, battery electrodes, superconductors and other materials to reveal their atomic, molecular and electronic properties.

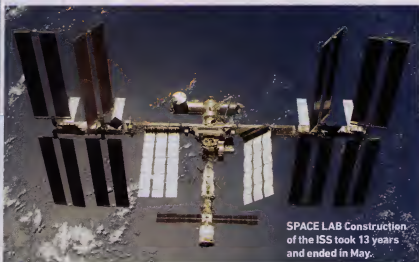
SCIENTIFIC UTILITY: The ALS is one of the brightest sources of soft x-rays, which have the right wavelengths for spectromicroscopy, a scientific technique that reveals both the structural and chemical makeup of samples only a few nanometers wide. In 2006, scientists at the ALS helped determine that dust captured from the tail of a comet formed near the sun very early in the solar system's history, showing that the cosmic ingredients that originated in our corner of the universe started mixing earlier

than we thought. That same year, Roger D. Kornberg of Stanford University won the Nobel Prize in Chemistry for work at the ALS on the 3-D structure of RNA polymerase enzymes. The structural data allowed him to describe how DNA is translated into RNA during a process called transcription.

WHAT'S IN IT FOR YOU: Work at the ALS on a protein associated with melanoma aided the development of a novel medication to combat the disease. The drug is currently in Phase II and III clinical trials. Other data from ALS could lead to high-capacity lithium battery electrodes, which would increase the battery's charge capacity. Finally, understanding the physical and electronic structure of flat sheets of carbon, called graphene, could spur the development of atomic-scale transistors and much faster computer processors.—J.A.

FIAT LUX The ALS produces x-rays in a device called an undulator, seen here.





SPACE LAB Construction of the ISS took 13 years and ended in May.

INTERNATIONAL SPACE STATION

AN ORBITAL LABORATORY

It takes \$2 billion a year and thousands of employees to keep the lights on at the International Space Station. So far, 201 people from 11 countries (and seven well-heeled tourists) have visited the ISS, which has supported the longest continuous human presence in orbit: 11 years this November, with about a decade more to come. The ISS also plays host to the Alpha Magnetic Spectrometer (AMS), the largest, heaviest instrument ever to be flown in space.

SCIENTIFIC UTILITY: On the ISS, scientists and astronauts from NASA and its international partners test spacecraft components and support systems that could be used for long-distance human spaceflight. They also examine human physiology, studying the effects of weightlessness on bone density and red-blood-cell production and how the immune system changes during long periods in space. As of May, researchers have had access to the AMS, an instrument capable of detecting strangelets, quarks that have been made in particle accelerators but have never been observed in nature.

WHAT'S IN IT FOR YOU: Research performed on the ISS led to the discovery that salmonella bacteria become more virulent in space. That discovery, and the identification of the genes that cause the change, are fueling the development of the first vaccines to combat salmonella and methicillin-resistant *Staphylococcus aureus* (MRSA) bacteria, the staph infection that has plagued thousands of hospital patients. —J.A.



Annual budget: \$2,310,000,000
Construction cost: \$4,500,000,000
Staff: 1,000–2,000
Physical size: 32,333 cubic feet
Scientific utility: 3
WIFIF: 6
Wow factor: 6



▲ **BACKSTOP** The backscatter ring spectrometer in the SNS tracks how neutrons scatter off atomic nuclei.

SPALLATION NEUTRON SOURCE

A MOVIE CAMERA FOR MOLECULES

Every month, the Spallation Neutron Source in Oak Ridge, Tennessee, draws between 25 and 28 megawatts of power from the electrical grid and uses about 8.5 million gallons of water to stay cool. During operation, the particle accelerator in the SNS sends bursts of two



Annual budget: \$168,000,000
Construction cost: \$1,410,000,000
Staff: 500
Physical size: N/A
Scientific utility: 10
WIFY: 10
Wow factor: 1

◀ ON A PEDESTAL
Technicians at the SNS use a special boom to perform maintenance on the machine's hazardous components.

quadrillion neutrons per pulse down into a target chamber. These dense clouds of neutrons deflect off materials to reveal how atomic structures change over time.

SCIENTIFIC UTILITY: The SNS sends particles hurtling toward a sample at up to 97 percent of the speed of light. But unlike particles in a collider, neutrons do not create large explosions when they hit their sample. Because they are small and

have very little energy, neutrons interact only weakly with matter. As the neutrons pass through a sample, they scatter off the atomic nuclei in the sample. That interaction changes the energy and direction of those neutrons, and 14 different instruments, positioned a few feet from the sample, record those changes in trajectory. Software then adds up all the scattering data to produce the atomic structure of the sample. Because the SNS

sends packets of neutrons at a rate of 60 pulses per second, it can record how structures change over time, like shooting individual frames of a movie and then stitching those together into motion.

WHAT'S IN IT FOR YOU: Better batteries. Scientists are using these atomic-scale movies to monitor batteries as they charge and discharge in real time. It will also be used to study protein structure.—G.M.

LARGE HADRON COLLIDER

A PROTON ACCELERATOR TO FIND
THE ELUSIVE GOD PARTICLE

Buried 330 feet beneath the border of Switzerland and France, the Large Hadron Collider is the world's largest particle collider. The facility requires 700 gigawatt-hours of energy and some \$1 billion annually to run. More than 10,000 researchers, engineers and students from 60 countries on six continents contribute to the LHC's six standing projects, which are designed to unlock the fundamental physics of the universe.

SCIENTIFIC UTILITY: What exactly is dark matter? Are there extra dimensions in space? Does the Higgs boson, commonly referred to as the "God particle," exist? How did the universe form? The LHC's six particle detectors record



Annual budget: \$1,200,000,000
Construction cost: \$7,820,000,000
Staff: 2,500
Physical size: 17-mile circumference
Scientific utility: 8
WIIFY: 1
Wow factor: 9

and visualize the paths, energies and identities of subatomic particles, which may answer some of these questions. The ATLAS project's detector, for example, is searching for collision events in which there appears to be an imbalance of momentum—an indication of the presence of the supersymmetric particles thought to make up dark matter. The Compact Muon Solenoid project complements ATLAS by searching for supersymmetry and the elusive Higgs boson. LHC-Forward will simulate high-energy cosmic rays, and LHC-Beauty will provide information on why the universe is made up of matter rather than antimatter. TOTEM tracks proton collisions and provides data on the proton's inner structure. And ALICE will track quark-gluon plasmas, similar to experiments

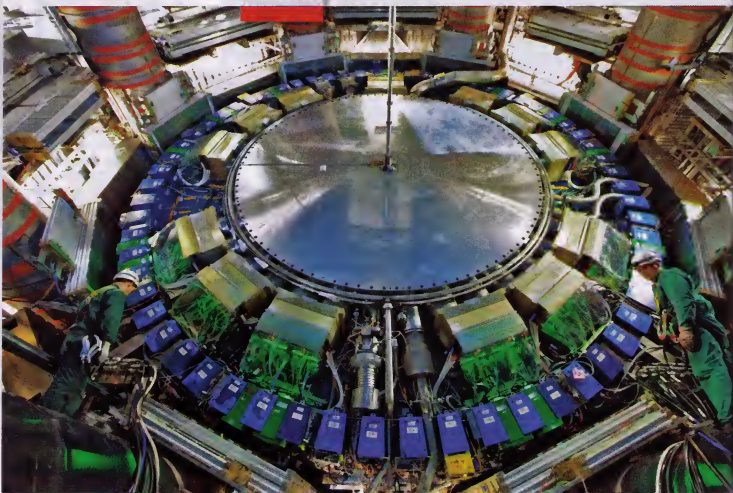


GUT CHECK Inside the ATLAS detector at the LHC

conducted at the Relativistic Heavy Ion Collider (#10 on our list).

WHAT'S IN IT FOR YOU: Though the LHC has brought black-hole alarmists out of the woodwork, the project will have little effect on our day-to-day lives, unless your family and friends are the type to discuss the origins of the universe over dinner.—K.B.

▼ **HEAT SEEKER** A calorimeter in the ATLAS detector measures the energy of particles.





EARTHSCOPE

A TELESCOPE TO PEER DEEP INTO THE HEART OF OUR PLANET

Designed to track North America's geological evolution, EarthScope is the largest science project on the planet. This earth-sciences observatory records data over 3.8 million square miles. Since 2003, its more than 4,000 instruments have amassed 67 terabytes of data—that's equivalent to more than a quarter of the data in the Library of Congress—and add another terabyte every six to eight weeks

SCIENTIFIC UTILITY: Researchers are using EarthScope, which consists of many kinds of experiments, to examine all facets of North America's geological composition. Across the continental U.S. and Puerto Rico, 1,100 permanent GPS units track deformations in the land's surface

caused by tectonic shifts below. Seismic sensors next to the active San Andreas Fault in California record its tiniest slips, while rock samples pulled from a drill site that extends two miles into the fault reveal the grinding and strain on the rocks that occur when the two sides of the fault slide past each other during an earthquake. And over the course of 10 years, small crews have hauled a moveable array of 400 seismographs across the country using backhoes and sweat. By the time the stations reach the East Coast next year, they will have collected data from almost 2,000 locations.

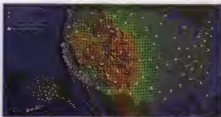
WHAT'S IN IT FOR YOU: Collectively, EarthScope's measurements could help explain the forces



Annual budget:
\$25,000,000
Construction cost:
\$197,000,000
Staff: 110
Physical size:
3.8 million square miles
Scientific utility: 10
WIIFY: 10
Wow factor: 10

▲ **MOTION SENSOR GPS** stations pinpoint areas of ground movement down to the thickness of a dime.

behind geological events such as earthquakes and volcanic eruptions, leading to better detection. So far, data from the project has shown that rocks in the San Andreas Fault are weaker than those outside it and that the plume of magma under Yellowstone's supervolcano is even bigger than previously suspected.—B.B.



▲ **DRAGNET** Earthscope deploys GPS stations, strain meters, and permanent and mobile seismic stations across the U.S.



The Man Who Would Stop Time

Bill Andrews has spent two decades unlocking the molecular mechanisms of aging. His mission: to extend the human life span to 150 years, or die trying

BY JOSEPH HOOPER

PHOTOGRAPHS BY JOHN B. CARNETT ILLUSTRATION BY ALBERTO SEVESO

BILL ANDREWS'S FEET are so large, he tells me, that back when he was 20 he was able to break the Southern California barefoot-waterskiing distance record the first time he put skin to water. Then he got ambitious and went for the world speed record. When the towrope broke at 80 mph, he says, "they pulled me out of the water on a stretcher."

The soles of the size-15 New Balances that today shelter those impressive feet strike a steady clap-clap on the macadam as Andrews and I lope down a path along the Truckee River that takes us away from the clutter of cut-rate casino hotels, strip malls and highway exit ramps that is downtown Reno, Nevada. Andrews, 59, is a lean 6-foot-3 and wears a close-cropped salt-and-pepper Vandyke and, for today's outing, a silver running jacket, nicely completing a package that suggests a *Right Stuff*-era astronaut. He is in fact one of the better ultramarathoners in America. I am an out-of-shape former occasional runner, so it gives me pause to listen as Andrews describes his racing exploits. "I can run 100 miles, finish, turn around, and meet friends of mine on the course who are still coming in," he says. "I've been in many races where I'm stepping over bodies of people who have collapsed, and I'm feeling great."

His return to running after a middle-aged break was, he says, inspired by a revelation he had at a time when he and a small team of scientists at his biotech start-up, Sierra Sciences, had been working 14 to 18 hours a day

in the lab for five years, rather obsessively pursuing a particular breakthrough. Finally, his doctor told him he was headed for an early grave. "I thought, god, I don't want to cure aging and then drop dead," Andrews says.

That would indeed be ironic. Because Andrews does intend to cure aging. This stated ambition induces in some listeners the suspicion that Andrews might suffer from delusions of grandeur, but he has a scientific pedigree that insists he be taken seriously. Unlike his friend Aubrey de Grey, the University of Cambridge longevity theorist who relentlessly generates media attention with speculations that straddle the border between science and science fiction, Andrews is an actual research scientist, a top-drawer molecular biologist.

In the 1990s, as the director of molecular biology at the Bay Area biotech firm Geron, Andrews helped lead a team of researchers that, in alliance with a lab at the University of Colorado, just barely beat out the Massachusetts Institute of Technology in a furious, near-decade-long race to identify the human telomerase gene. That this basic science took on the trappings of a frenzied Great Race is a testament to the biological preciousness of telomerase, an enzyme that maintains the ends of our cells' chromosomes, called telomeres. Telomeres get shorter each time a cell divides, and when they get too short the cell can no longer make fresh copies of itself. If we live long enough, the tissues and organ systems that depend on continued cell replication begin to falter: The

skin sags, the internal organs grow slack, the immune-system response weakens such that the next chest cold could be our last. But what if we could induce our bodies to express more telomerase? We'll see, because that is what Andrews intends to do.

Andrews had scheduled this afternoon's run as an 18-miler, but he graciously downscaled those ambitions on my behalf long before we set out from the parking lot of the Grand Sierra Resort Hotel. Four miles in, he's hardly winded—and I'm out of gas. As we make our way back to his car, he consults his training watch and informs me that our pace was an almost respectable 8:40, excepting the latter stretches when I walked, pushing our average up to 10 minutes a mile.

The embrace of fitness has for Andrews a telomeric logic. Make poor lifestyle choices, and you're likely to die of heart disease or cancer or *something* well before your telomeres would otherwise become life-threateningly short. But for the aerobicized Andrews, for anyone who takes reasonable care of himself, a drug that activates telomerase might slow down the baseline rate at which the body falls apart. Andrews likens the underlying causes of aging, free radicals and the rest, to sticks of dynamite, with truncated telomeres being the stick with the shortest fuse. "I believe there's a really good chance that if we defuse that stick," he says, "and the person doesn't smoke and doesn't get obese, it wouldn't be surprising if they lived to be 150 years old. That means they're going to have 50 more years to be around when somebody solves the other aging problems."

But in his race to cure aging, Andrews may himself be running out of time. The stock-market crash of 2008 nearly wiped out two investors who had until then been his primary funders. Without the money to continue refining the nearly 40 telomerase-activating chemicals he and his team had already discovered, Andrews made the decision last September to cut a deal with John W. Anderson, the founder of Isagenix, an Arizona-based "network marketing" supplement company. This month, Isagenix will launch an anti-aging product containing several natural compounds that Sierra Sciences has verified to have "telomere-supporting" properties. It's not the powerful drug Andrews originally envisioned, but he says he believes it will promote "health and well-being" and just possibly generate enough cash to underwrite the expensive "medicinal chemistry" required to come up with a more fully developed anti-aging compound—

"I WANT TO CURE MY AGING, MY FRIENDS' AND FAMILY'S AGING, MY INVESTORS' AGING, AND I WANT TO MAKE A TON OF MONEY," ANDREWS SAYS.

one attractive enough to bring in a billionaire or a Big Pharma partner with pockets deep enough to take a drug candidate through the FDA's time-consuming and fabulously expensive approval process.

"I want to cure my aging," Andrews tells me, "my friends' and family's aging, my investors' aging, their friends' and families' aging, and make a ton of money. And I want to cure everybody else's aging too—I put that probably equal to making a ton of money."

DOCTORS TEND to look at bodily decline through the prism of so-called diseases of aging, our increasing susceptibility over time to killers like cancer and heart disease. But in the 1950s, research biologists began to view aging itself as the disease. When free radicals scavenge electrons from their neighbors, they set in motion some ugly chain reactions. Cholesterol molecules become oxidized and begin to interact with the artery walls to form atherosclerosis-causing plaque, for instance, or the DNA in the cell nucleus suffers mutations, laying the groundwork for cancer. Later refinements of this theory emphasize the role of the mitochondria, the cellular power plants that help convert glucose into energy. As the mitochondria age, they spew out increasing amounts of the free radicals that hamper energy production and damage the entire cell, accelerating our all-systems decline.

Among cell biologists, these mechanisms remain to this day the most accepted ways of explaining what's happening to that face reflecting back at us in our bathroom mirror. But telomere science has opened up the possibility of drilling even deeper into the molecular bedrock of aging. The fledgling field was energized in 1984, when biochemist Elizabeth Blackburn of the University of California at Berkeley and her then-grad student Carol Greider discovered the telomerase enzyme in a pond-scum protozoan, an achievement that won them a Nobel Prize. Since then, our picture of human telomeres and telomerase has sharpened considerably. Telomeres are made of repeating sequences of six

A BRIEF HISTORY OF IMMORTALITY



• Antiquity •

According to Greek mythology, the goddess Eos asked Zeus to confer immortality on her Trojan lover Tithonus so she could enjoy his favors eternally. In one of the early "be careful what you wish for" tales, Eos forgot to specify eternal youth and Tithonus eventually passed into never-ending decrepitude. Eos shut him in a room where he babbled to himself for the rest of time.



YOUTH ELIXIR
Bill Andrews examines one of tens of thousands of compounds he has screened for anti-aging properties.

DNA bases—two thymine, one adenine, three guanine (TTAGGG)—that serve to “cap” chromosomes, preventing potentially cancerous breaks; the analogy usually trotted out is the plastic aglet that prevents a shoelace from fraying at the ends. Telomeres also assist cell division. Every time a cell splits, the ends of its chromosomes fail to get fully copied in the two new daughter cells, and a bit of telomeric DNA gets lost. No harm is done to the rest of the chromosome, but in cells that divide frequently, the telomeres shorten with each replication. Telomerase’s job is to synthesize new DNA to add to the shrinking telomeres, slowing down the decline.

Human life, it turns out, is a losing effort to hang on to our telomeres. At conception, telomeres have roughly 15,000 DNA base pairs. Because telomerase can’t keep up with rapid cell division in utero, they shrink to about 10,000 base pairs at birth. At that point, the telomerase gene is mostly turned off. Without the enzyme, we continue to lose telomeric DNA—once we’re out of our

teens, usually at a rate of 50 base pairs a year. By the time some of our telomeres drop below about 5,000 base pairs, typically well into our “golden” years, our cells may have lost the ability to divide. They become senescent, bad at doing the work they were designed to do but good at doing things like releasing inflammatory chemicals that harm their neighbors. Or they may be targeted for cell death.

Andrews sounds almost giddy when he describes the “aha” moment 20 years ago when he first heard his soon-to-be boss at Geron, pioneering telomere biologist Calvin Harley, lecture about telomeres as a “mitotic clock,” in which the steady shortening of the telomeres serves as the tick-tock of the aging cell. “I was floored,” Andrews says. He found the lockstep precision suggestive by the metaphor irresistible.

Cultured in the lab, cells can divide just 50 to 70 times before packing it in (this is known as the Hayflick Limit, after longevity-research eminence Leonard Hay-

PAUL WOOTTON

13th century

The English philosopher Roger Bacon writes that aging is caused by the progressive loss of vital spirit, or “innate moisture.” To extend their life span, he advised old men to spend time in the company of young women, thereby absorbing their sweet, moist breath.



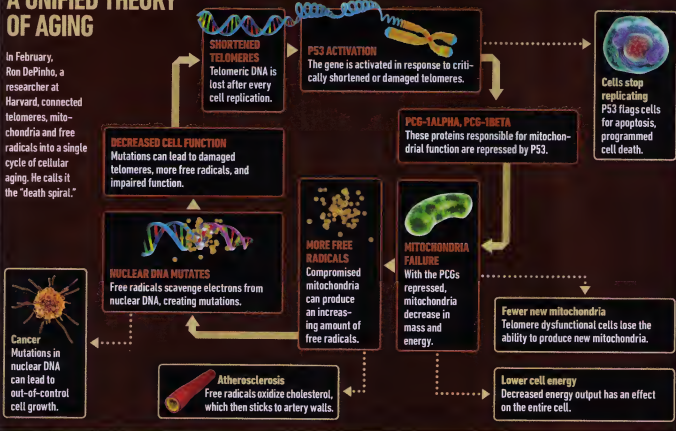
1523

Juan Ponce de León, the first governor of Puerto Rico, discovers what is now Florida while supposedly searching for the Fountain of Youth. Legend has it that the 55-year-old Spanish explorer, who was married to a much younger woman, was looking for a semitropical Viagra. Though no documentary evidence exists, the story of the failed quest was widely promoted by subsequent biographers and historians.



A UNIFIED THEORY OF AGING

In February, Ron DePinho, a researcher at Harvard, connected telomeres, mitochondria and free radicals into a single cycle of cellular aging. He calls it the "death spiral."



flick, who discovered the phenomenon). The human body is significantly more complex than a petri dish, but some similar limit must be enforced there, Andrews says, to account for the fact that the maximum human life span is so tightly regulated, with the longest-lived humans making it to 100 and, to the best of our knowledge, nobody surviving past 125. If free-radical damage were really the primary driver of aging, he says, people's rate of bodily decline would vary widely based on the amount of environmental damage they had absorbed, a major contributor to the free-radical load, and therefore so would their maximum life span. "But you can look at a person and have a 95 percent chance of guessing their age within five years," he says. "There has to be some kind of internal clock ticking inside of us."

Biologists continue to debate the extent to which aging at the cell level determines the aging of the whole organism. Most have argued that short or damaged

telomeres aren't as big a deal as Andrews, or even the more measured Harley, make them out to be. Tissues and organ systems that depend on cell division have a fair amount of reserve capacity, and the cells that seem to play the biggest role in their decline, neurons and heart-muscle cells, hardly replicate at all.

But over the past few years, the case for telomeres as a major player in aging, possibly even the prime mover, has grown stronger. Heart health, telomere biologists point out, depends heavily on the endothelial cells that line the blood vessels, and brain health on the glial and schwann cells that make the myelin that protects neurons, all of which are cell types that hear the ticking of the mitotic clock. And last year, Harvard University researcher Ron DePinho published two studies in the journal *Nature* that have reframed the debate about telomerase activation. DePinho created an ingenious model whereby he could turn telomerase off in a mouse

1726



Jonathan Swift publishes *Gulliver's Travels*, especially memorable for its depiction of the Struldbruggs, who are born immortal with red dots on their forehead. Gulliver is delighted with his discovery of the Struldbruggs until he learns that they're doomed to eternal old age. Their hair and teeth fall out, and they gradually lose the ability to speak with their fellow Luggnaggians, unable to keep up with changes in the language.

1889



French physician Charles-Édouard Brown-Séquard recommends the dried and ground sex glands of guinea pigs and dogs as a tonic to extend youthfulness and virility. He sets off a craze for rejuvenation injections and even human-testes transplants.

"A MAGIC PILL?" SAYS NOBEL PRIZE WINNER**ELIZABETH BLACKBURN. "I THINK WE'VE BEEN****THERE ABOUT A MILLION TIMES BEFORE."**

and then restore it, simply by administering, or withholding, a synthetic estrogen drug. In the first study, the mice with turned-off telomerase exhibited signs and symptoms of decrepitude akin to what we might endure at the age of 80 or 90: wrinkled skin, sluggish intestines, shrunken brain. When telomerase production was turned back on, the tissues rejuvenated within a month. "We treated these animals that were the equivalent of your grandmother," DePinho says, "and they became like young adults." He says he had expected to be able to stop or slow down the rate of aging. What he found was the proof-of-concept that living tissue could actually go back in time. (When Andrews talks about the possibility of running a seven-minute mile at the age of 130, he's got the Harvard mice for backup.)

The second *Nature* paper was DePinho's attempt at developing a unified theory of late-life aging, "the death spiral," as he calls it, that can transform a spry, alert 80-year-old into a shell of herself at 90 or 100 even in the absence of diagnosable disease. His mice data suggest that the major aging processes—free-radical damage, mitochondrial dysfunction, and short or damaged telomeres—interrelate and that the telomeres can instigate decline, acting as the first domino that sets in motion the rest. If the telomeres can be preserved, the entire system may be granted at least a temporary reprieve.

DePinho says he envisions more animal-model research leading to human clinical trials leading—years or, more likely, decades down the road—to FDA-approved drugs. The high-speed, low-rent workarounds of a telomerase-activating supplement beyond the reach of the FDA doesn't please him. "Even if you did get telomerase activity," he says, "you sure as hell would want to know where and when to turn it on. Telomerase can be deleterious as well." Elizabeth Blackburn, now at the University of California at San Francisco, has reservations about a good-for-what ails-you supplement. "A magic pill?" she says. "I think we've been there about a million times before in human history."



MISSION CONTROL
At Sierra Sciences, an eight-person lab staff works to discern the molecular mechanisms of the enzyme telomerase.

SIERRA SCIENCES operates out of a small, dun-colored office park near downtown Reno. From the outside, it could be mistaken for a Sun Belt Staples, but inside are touches that speak to Andrews's specific history and sense of mission. He walks me into a conference room decorated with plaques commemorating U.S. patents issued, and a whiteboard with an "Aging Sucks" bumper sticker plastered on it. "Dad sent that," Andrews says, identifying the handiwork of Ralph Andrews, a retired Los Angeles game-show producer (his biggest hit was *You Don't Say!*, which ruled the daytime airwaves in the 1960s). For reasons Andrews can't adequately explain, his father, still hale at 84, has always been dead set against aging, and once suggested to his preteen son that he might want to take a shot at solving the problem. "My dad probably told me to do a lot of things, but this just struck a chord," he says. "I never thought aging was inevitable. I just thought nobody had figured it out yet."

In the late '90s, Andrews came to feel that Geron had lost the true telomerase-activating religion, having redirected most of its resources into stem-cell therapies. He left Geron, crossed the Sierras, and in 1999 gathered around him in the Nevada desert a small circle of researchers who believed almost as ardently as he that it might be possible to engineer a "small molecule" drug that would flip the telomerase gene's "on" switch inside a living human body. Since then, the company has gone through two distinct phases, pre-crash and post-crash. In the first era, two especially beneficent investors unquestioningly underwrote his efforts to crack the telomerase code. (Start-ups working on an actual product in development attract venture capitalists. More-speculative ventures like Sierra Sciences typically draw individual "angels"—in the anti-aging field, often older, wealthy men willing to risk losing money in the hopes that somebody will come up with a way to extend their fruitful lives.)

During this first phase, Andrews and his team deployed an elegant recombinant DNA approach, arguably better suited to an academic lab than a start-up that needed marketable results. They would painstakingly alter one or two DNA bases out of the thousands that make up the telomerase gene, cycling through thousands of slight variations in an effort to find one that the regulatory molecule that normally keeps the gene turned off, the "repressor," would no longer recognize. This would reveal the molecular identity of the repressor, and the team could then create a drug to neutralize it—repressing the repres-

PHOTOGRAPHY COURTESY DAVID BUNNELL

1964



Physicist Robert Ettinger publishes *The Prospect of Immortality*, introducing the idea of "cryonics," the preservation of the human body by freezing until the time when advanced technologies can revive it. In 1972 the company Alcor, now in Scottsdale, Arizona, was born, and in 1976 it performed the first "cryopreservation." You can preserve your entire body or just your head, and the price varies accordingly.

1996



William Regelson publishes *The Melatonin Miracle*, which inspires a *Newsweek* cover story and ignites a fad for "Nature's Age-Reversing, Disease-Fighting, Sex-Enhancing Hormone." The original studies behind the book have since been somewhat discredited.

BEAT THE CLOCK

Bill Andrews has run more than 100 races of 50 miles or more. His longest ever was 135 miles through Death Valley, California.



"UNEQUIVOCALLY, HE'S PAID A PRICE WITH HIS SCIENTIFIC PEERS," FEDERICO GAETA SAYS.

"HOW BIG, I DON'T KNOW. BUT BILL'S

NOT GOING TO BREAK."

sor and switching the telomerase gene back on.

By 2006, after seven years of effort and one excruciatingly close miss (they found "a" repressor but apparently not "the" repressor), Andrews finally shifted strategies. If developing a telomerase-activating drug with recombinant-DNA methods was a bit like trying to find a needle in the haystack by analyzing the haystack molecule by molecule, the new approach was brute force: Grab a pitchfork and start digging. The company bought libraries of several hundred thousand chemical compounds and tested each one to see if it would activate telomerase in cultured human cells.

The cells Andrews chose were fibroblasts, which are found in skin and connective tissue and which are relatively cheap and easy to culture. They also have little ability to express telomerase in a lab setting. When Andrews first started the company, he ran into skepticism from some of his high-profile scientific advisers, who doubted his overall strategy of trying to turn on telomerase. "They were even laughing at it," he says. Now at this later stage of the game, a few of his paid consultants questioned his decision to use fibroblasts. "Bill is the most persistent guy I've ever met," says Bryant Villeponteau, a Geron alum and a former Sierra Sciences consultant. "Sometimes if he's committed to something, he will go beyond the point where it's wise."

But Andrews had his reasons—the fibroblasts behave themselves in the lab and don't change into other cell types, unlike stem cells, which can be moving targets. And after a year and a half of testing for telomerase activation, running compound after compound through a screening assay, he finally caught a break. On the 57,684th run, the team got a chemical hit. Coosy684 was too toxic to be easily transformed into a drug prospect, but it gave the company a positive control. In other words, they could use it to tune their detection tests to recognize fainter and fainter levels of telomerase activation, which is essential when you're working with stodgy, underperforming fibroblasts.

By then, however, the market crash of 2008 had

clipped the wings of the company's two angels, radically altering Andrews's job description. Rather than spending his days and nights in the lab, he became a telomerase-activation evangelist, crisscrossing the country in search of funding. "Where's Bill?" became a regular link on the company's website. His doleful SOS bounced around the life-extension blogosphere: "The bottom line is that Sierra Sciences needs \$200,000 per month as soon as possible."

The worst part for Andrews was leaving the day-to-day responsibilities of the lab and retreating to his office, where he works the phones and e-mail trying to pilot the company out of financial peril. The long hours and personal austerity required by the new mission are by now second nature and, this afternoon, become grist for an enthusiastic show-and-tell. The office fridge: "For breakfast, I have a protein shake, and every two weeks I go to Trader Joe's or Whole Foods and buy a whole bunch of frozen foods that I heat up for dinners." The low-slung chest of drawers with the cushion on top where he spends many of his nights, cutting down on the commute in from his ranch 25 miles outside of town: "My legs overhang the edge, but that's OK. If I bend my knees, my legs are on the cushion." (The last bed I saw with such awkward dimensions belonged to Father Junipero Serra, the 18th-century founder of the California Franciscan missions—his attempt to mortify the flesh presented a resonant contrast to Andrews's efforts to make it something closer to immortal.)

For all the monastic devotion he brings to the cause, Andrews is a pure gene jock. It's a sign of our nutraceutical-besotted times that such a scientist has made a marriage of convenience with a supplement industry often equated with hippie herb lovers and cynical marketers looking to exploit the next pseudoscience fad. Gone are the bulk shipments of synthetic chemicals to be assayed, replaced by a small weekly delivery of ingredients derived mostly from traditional Chinese and Indian medicinal herbs that John W. Anderson prepares in his five-man Arizona lab. To Andrews's surprise (and considerable relief), at least three of these compounds have tested positive for telomerase activation in the lab, even though many of the source materials are readily available in health-food stores. Have longtime devotees of traditional Chinese and Indian medicinal

CONTINUED ON PAGE 791

PALESTROTTON

2005

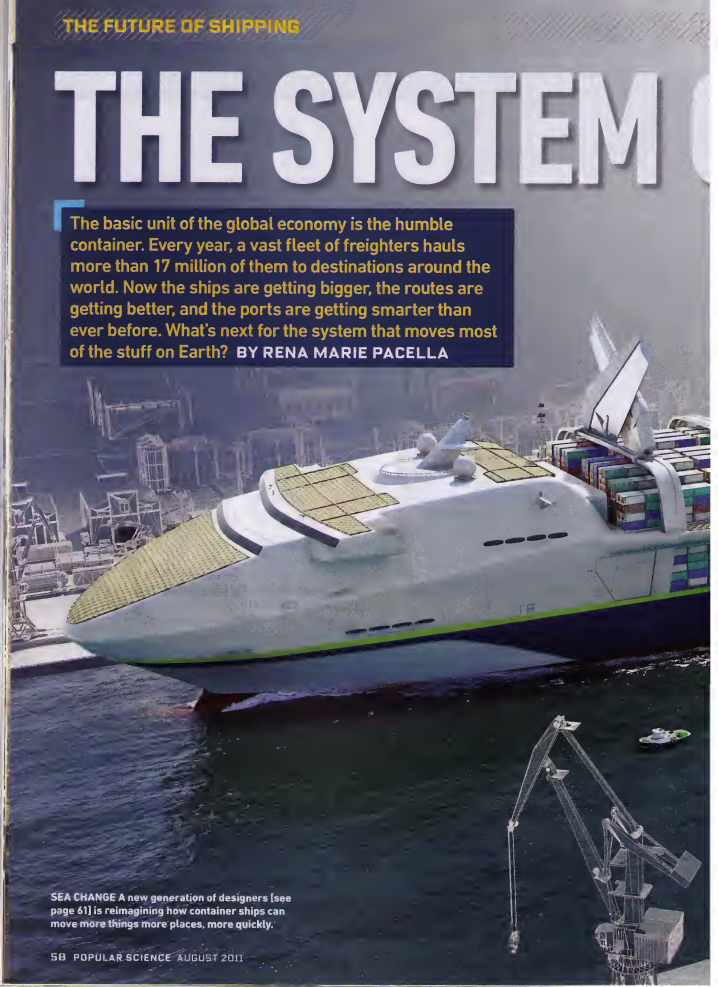
Futurist and inventor Ray Kurzweil publishes his best-selling *The Singularity Is Near*. In it, he writes that in the not-so-distant future, the human brain may be uploaded to a computer, creating functional immortality, although our bodies won't be around to enjoy it.

2008

British pharmaceutical giant GlaxoSmithKline pays \$720 million to buy Sirtis, the start-up that discovered that resveratrol, a compound found in red grape skins, extended the life span of obese lab rats. Sirtis co-founder David Sinclair devised potent resveratrol "analogues," but since then, two major labs have failed to reproduce his results. Glaxo has announced that it has stopped work on the original compound.

THE SYSTEM

The basic unit of the global economy is the humble container. Every year, a vast fleet of freighters hauls more than 17 million of them to destinations around the world. Now the ships are getting bigger, the routes are getting better, and the ports are getting smarter than ever before. What's next for the system that moves most of the stuff on Earth? **BY RENA MARIE PACELLA**



SEA CHANGE A new generation of designers [see page 61] is reimagining how container ships can move more things more places, more quickly.

OF THE WORLD



BASIC UNITS

A sensor-packed shipping container that folds flat in 30 seconds

In the half-century since Malcom McLean, an entrepreneurial former trucker from North Carolina, first began packing freight onto ships in uniform steel boxes, shipping containers have transformed the way we move most of the goods on Earth. As McLean recognized, cargo with consistent dimensions becomes a commodity. Any box can go anywhere on any ship, and therefore can be moved and stored far more cheaply and quickly than cargo that comes in a hodgepodge of shapes and sizes.

The containers themselves have not changed much in 50 years, though. They are still 20 or 40 feet long, and they are still heavy, rust-prone and dumbly inert. Dutch inventor René Giesbers might have the perfect update: a light, collapsible container called the Cargoshell, made of composite materials that are transparent to security scanners and tracking sensors. Giesbers has competition, however, including the U.S. Department of Homeland Security, which has spent approximately \$60 million to design its own composite containers and new sensors. Some of these features should start appearing in the global supply chain in the next few years.

COMPOSITE BODY

As strong as steel and up to five times as corrosion-resistant, fiber-reinforced polymer walls make the box lighter and easier to scan than today's containers.

COLLAPSIBLE FRAME

For more efficient storage and transportation when empty, the box can be folded to a quarter of its full height in just 30 seconds. The doors roll into the roof, and the walls collapse inward.

MONITORS

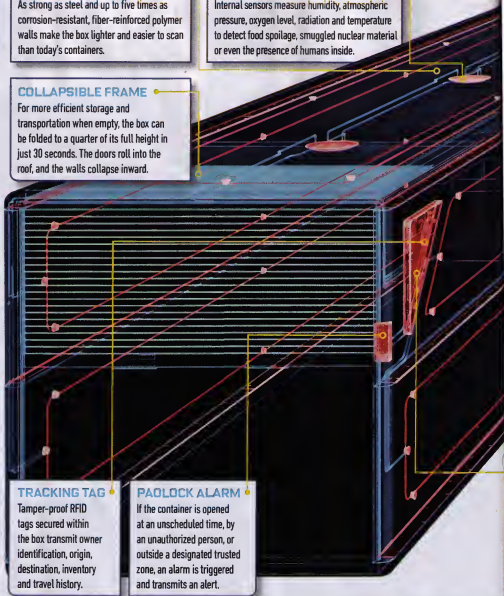
Internal sensors measure humidity, atmospheric pressure, oxygen level, radiation and temperature to detect food spoilage, smuggled nuclear material or even the presence of humans inside.

TRACKING TAG

Tamper-proof RFID tags secured within the box transmit owner identification, origin, destination, inventory and travel history.

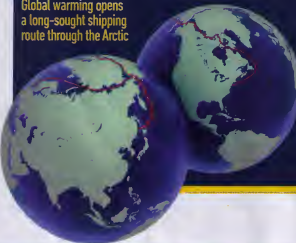
PADLOCK ALARM

If the container is opened at an unscheduled time, by an unauthorized person, or outside a designated trusted zone, an alarm is triggered and transmits an alert.



SHORT CUTS

Global warming opens a long-sought shipping route through the Arctic



For a few short weeks last September, the Northwest and Northeast Passages through the Arctic Ocean were simultaneously ice-free from end to end, the first such clearing in the time that satellites have monitored the region. Merchants have long sought routes through the ice-packed waters that link the Pacific and Atlantic. But researchers at the Naval Postgraduate School in Monterey, California, say that we could now

see an entire Arctic Ocean, not just passages along the coasts, with ice-free summers, as soon as 2016.

That is a bleak environmental scenario. But it also means that cargo ships could shave thousands of miles off their journeys. Already, Russia is touting the Northeast Passage (a.k.a. the Northern Sea Route), which hugs its Arctic coast, as a shorter, safer alternative to the pirate-infested waters near Egypt's Suez Canal. The country's



CargoXpress

MOVING IN BULK

Imagining (and in some cases building) much bigger and more efficient carriers

Green Giant

Once it is completed, the \$190-million Maersk Triple E will be the world's largest and most efficient class of container ships. Its 1,312-foot-long, U-shaped hull will hold 18,000 containers—about 2,000 more than the next biggest ship. Whereas most container ships are propelled by a single diesel engine, the Triple E has two. But even traveling at 19 knots, it will require only half as much fuel to deliver its cargo, in part because of recovery of engine waste heat. South Korea-based Daewoo Shipbuilding and Marine Engineering will complete the first 10 for Maersk by 2015.

Natural Gas

The Quantum 9000, now just a concept from the Norwegian ship-standards firm DNV, would be the first container ship to run on liquid natural gas, or LNG, the cleanest available marine fossil fuel. Making the switch would reduce carbon dioxide emissions by 30 percent, nitrogen oxide emissions by 80 percent, and sulfur oxide emissions by 95 percent. The Quantum 9000 would be “midsized”—that is, big enough to carry nearly 9,000 containers in its 1,030-foot-long hull but still small enough to fit through the soon-to-be expanded Panama Canal (see page 63).

Modular Hybrid

When the 8,000-container NYK Super Eco Ship arrives at a port, it splits into four segments. The middle two units dock, and the forward and aft sections reconnect and move on to pick up two new, fully stocked middle sections. The 1,158-foot-long Eco Ship concept, designed by Japanese shipping line NYK, would get most of the power needed to drive its electric propellers from container-size LNG fuel cells that the crew can swap out or add like cargo. Solar cells blanketing the entire upper decks and sides and eight retractable telescoping masts with lightweight airfoil sails provide the rest.

Transformer

German logistics engineer Volker Rosenkranz proposes the CargoXpress, a 200-container catamaran that transforms into a sailboat at sea and into a high-capacity loading crane when docked, making it perfect for short hauls between small ports. In favorable winds, the 203-foot-long superstructure flap would open like a clamshell to serve as a giant sail-wing; solar cells would give the electric-motor-driven propellers an extra boost of clean energy. At port, the superstructure would extend a cantilevered crane over the dock to transfer containers directly from ship to shore.

Wind Rider

The four-masted 377-foot-long Eco-liner from Dutch shipbuilder Fair Transport B.V. may be the first of a new fleet that uses sails for primary propulsion. Unlike traditional sailing ships with crisscrossing lines and rigging, the Eco-liner has four free-standing sails, each of which electronically rotates to achieve the best angle. When there's not enough wind, a diesel-electric engine kicks in to power a propeller. The Eco-liner, which can transport 200 containers using up to 90 percent less fuel than a similar-sized conventional vessel, could haul its first load by fall 2013.

TAMPER PROTECTION

A small electrical current runs through mesh embedded in the composite walls. Any breach that disturbs the flow of current will send an alert to the shipper, the receiver and the authorities at the destination port.

COMMUNICATIONS CENTER

An onboard computer draws data from monitors and sends encrypted updates by satellite or cellular network to the appropriate parties—owners, shippers, customs officials or port operators.



fleet of for-hire, icebreaker escorts are on duty, and more are on order. Although the major container shipping lines have yet to test the icy waters, more local cargo ships and tankers have been traversing the passage recently.

Equally desired is a shipping lane through the less-developed Northwest Passage on the Canadian side of the Arctic. Although a labyrinth of frozen islands makes transit more challenging, China

could get goods to the East Coast of the U.S. without a lengthy detour through the Panama Canal or an overland trip by railroad. Similarly, travel between the Northwest U.S. and Europe would be some 2,000 miles shorter. Many climate scientists say the Northwest could become passable on a regular basis by 2020.

Designers such as Aker Arctic, a Finnish firm, are developing ships that could travel the new routes even in the off-season, including icebreakers

that can move sideways to blast channels for big cargo ships, and container ships with reinforced sterns that plow through ice rear-end first so they don't need an icebreaker to accompany them. Meanwhile, the Arctic Regional Hydrographic Commission, formed last October, is coordinating efforts to map the more than 90 percent of Arctic waters for which nautical charts are decades out of date or nonexistent.



ANYBODY SEEN THE BRIDGE?

Piloting a massive container ship takes more than just a few charts

To plan their routes, the crews of transoceanic cargo ships have to assimilate a huge amount of information: from beacons and buoys, weather and navigation satellites, sensors onboard and on other ships, and from private companies that track rogue waves, pirate attacks and other oceanic

threats. Nonetheless, many crews still prefer to plot their course with paper charts and make adjustments manually. Next year, however, the United Nations International Maritime Organization (IMO) will require the crews of all large ships to switch to an electronic navigation system that reads certified digital nautical

charts. The IMO says the transition, which it expects to complete by 2018, will reduce collisions and groundings and also help crews select more clement and less pirate-ridden routes. Officials from Sperry Marine, the marine equipment arm of Northrop Grumman, say that crews will monitor the data on Electronic Chart Display and Information Systems, or ECDISs, that can integrate all incoming data and drive the ship's autopilot.

Route planner

Navigators view constantly updated route simulations and change routes on the fly based on environmental conditions, the ship's performance characteristics (fuel consumption, hull stress), the presence of other ships, and such scheduling constraints as container delivery time and berth availability.

Tracker

Radar and GPS track the vessel's position and display it on the chart, along with the nearby sea traffic. (Electronic sea charts update automatically via a broadband satellite connection to the Internet.)

Forecaster

Weather and oceanographic conditions (current and predicted) appear at regular waypoints along the charted route.



FINDING THE WAY
Many of these future navigation functions could be integrated into this already-in-use bridge system.

Obstacle avoider

Tailored to the specifications of a given ship and journey, the avoider alerts the crew only to those obstacles (seafloor wrecks, ice floes, naval exercises) that could possibly harm the ship or its cargo.

Diagnostic monitor

Personnel on shore can monitor onboard sensors for everything from container conditions to engine output as though they were on the ship.

Remote access

Through a satellite link, the shipping company can access the ship's operations or "black box" voyage data recorder.

Pirate detector

A pirate-threat program continuously assesses real-time information from onboard radar, sonar and cameras, together with warnings from long-range satellites and reports on recent attacks, and issues alerts to the route planner.



EXPANDING LANES

The Panama Canal gets an update

The century-old Panama Canal has a major shortcoming: New ships are too long, too deep and too wide to fit through it. By 2015, 40 percent of the world's fleet will have outgrown the roughly 50-mile-long passageway that is a key artery for goods headed from Asia to Europe and the U.S. Gulf and East coasts. Since 2008, the Panama Canal Authority has been leveling hillsides, excavating miles of new access channels to make room for the so-called post-Panamax ships. By the time the seven-year, \$5.25-billion project is complete, it will have dredged a total of 5.3 billion cubic feet of dirt, sand and mud.

But the biggest bottlenecks are at each end of the canal, where locks lift and lower ships into and out of the channels. Instead of enlarging the current locks, the port authority will build two more sets—one at each end—large enough to fit ships that are 1,200 feet long and 160 feet wide and that can carry 12,000 containers (2.5 times the current capacity). With major construction under way since March, the new locks will increase the canal's annual cargo capacity from 340 million to 600 million tons when they open in 2014.

The new locks will consist of three quarter-mile-long, 60-foot-deep chambers. A gate closes behind the ship, operators open a chute, and water rushes in. The water level raises 27 feet per chamber, and with it the ship. Gates then open to the next chamber. The old locks drew some 55 million gallons of water from an adjacent lake to raise the ship and then emptied it into the sea. In the new design, 60 percent of the water is recycled through three storage basins. The result is that even though the new locks are 30 percent bigger, they use 7 percent less freshwater per transit.



WIDE BERTH

By 2014, nearly a million containers a week will be able to pass through the Panama Canal.

AVAST! In 2009, Somali pirates fired on a U.S. Navy helicopter from a hijacked fishing boat.

PIRATE PUSHBACK

How to reverse the increasing number of attacks near the Suez Canal

Every month, some 1,300 ships heading to or from the Suez Canal must pass through the lawless waters off the coast of Somalia. Pirate attacks are at an all-time high—more than 200 have already been reported this year. As of May, pirates were holding more than 500 hostages and 26 hijacked ships, and companies are losing up to \$8.3 billion a year.

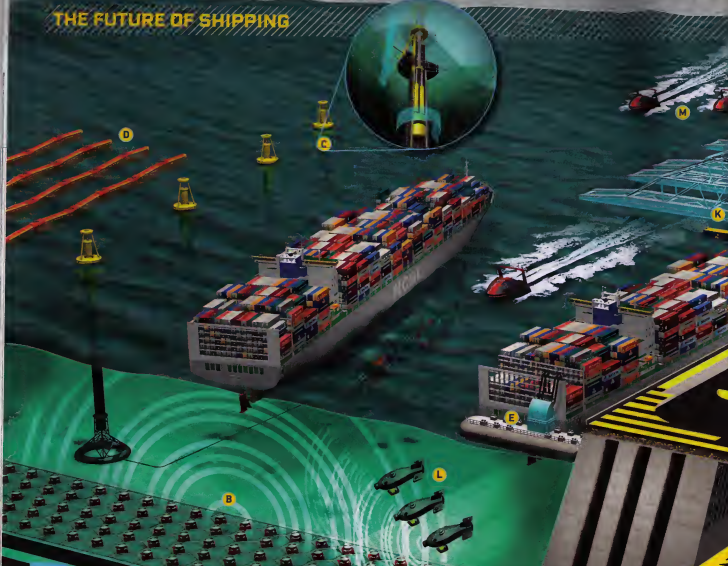
Cargo ships are easy prey, and with an area the size of the continental U.S. to patrol, even NATO and navy teams from several coastal countries can't protect every vessel. Bypassing the canal means a journey of thousands more miles around the Horn of Africa. The United Nations International Maritime Organization advises ships to speed up through high-risk areas, add more lookouts, and try other low-tech solutions that are not always effective against pirates with AK-47s and rocket-propelled grenades. Arming merchant ships with lethal weapons might solve the pirate

problem, but that approach would never gain international acceptance.

New nonlethal defenses, however, offer an alternative. BAE Systems is developing an onboard laser that could target unidentified vessels from more than a mile away. If the pirates continued to approach, the beam's intensity would disorient and temporarily blind them to the point that they couldn't aim and fire their own weapons. BAE tested a prototype of the laser in January.

Mace Security International, meanwhile, is testing a ship-mounted spraying system to keep pirates from boarding vessels. Three sets of 18-gallon pressurized tanks filled with oleoresin capsicum, a pepper derivative that is neither corrosive or flammable, would line the ship's perimeter. Attackers who ventured too close would be doused and immediately incapacitated for up to an hour by intensely burning eyes, skin and throat.





UNLOADING THE BOX

New port systems will almost completely eliminate the need for human labor. Nothing will be run manually because of the enormous complexity of moving the volume of cargo that future mega-ports will handle. The only human intervention will be at the network-engineering level, such as fixing software glitches and monitoring the integrity of computer hardware.

Control station

At least 24 hours before docking, a ship sends an electronic cargo manifest to the terminal's manager program (A), which coordinates and queues up the duties of the hundreds of autonomous machines needed to unload and reload a ship.

Seafloor scanners

As a ship enters the port, it must first pass through a pair of sonar arrays (B) on the seafloor that scan the bottom of the vessel for irregular shapes that could be bombs or smuggled goods hidden on the hull.

Wave energy

Offshore energy collectors (hydraulic buoys (C) and floating piston pumps (D)) located near the shore capture the energy from surface waves. Generators convert that energy into electricity and transmit it to shore by way of seafloor cables.

Plug-in power

Docked ships power down and plug into outlets (E) from which they can draw energy for communications and other systems. Providing shore-side power to a cargo vessel for one day reduces emissions and improves air quality near the port.

Ship unloaders

Stimmed-down horizontal container cranes (F) quickly pluck containers off the ship and place them onto robotic carts below. Instead of the bulky legs typical of conventional cranes, FastNet cranes, from Dutch company APM Terminals, have wheeled pillars that rearrange themselves beneath the elevated girders to avoid ground vehicles—all of which will double current loading and unloading speeds.

Container carts

Unmanned trucks, such as the new AutoShuttle (G) created by Finnish company Gargotec, pick up containers and, using RFID and optical character recognition, instantly retrieve identifying data and instructions on where to move them.



Electromagnetic floors

Electromagnets (H) embedded in terminal roadways wirelessly transfer energy to receiver coils on the undersides of electric port vehicles (today they are diesel or diesel-electric hybrids). Container carts, stackers and other mobile machinery pick up power as they carry out their duties and store it in either onboard battery packs or power-dense, quick-charging supercapacitors. Nebraska-based Conductix Wampfler and Swiss transport company Numexia are both already manufacturing energy-transfer systems that could be adapted for ports.

Stacking cranes

Three-story-tall autonomous, energy-efficient maglev cranes (I) rearrange containers into seven-box-high stacks in the container yard. In the rail yard, they load containers onto the beds of waiting semi trucks or freight cars.

Storage silos

Secure, climate-controlled underground storage facilities (J) rely on automated tracking systems that communicate directly with container computers and the port-manager program to arrange and locate cargo.

Cargo screeners

A compact particle accelerator (K) beams high-energy photons through containers. High-resolution detectors measure how the photons scatter or get absorbed to determine the composition and shape of the objects inside.

Port patrollers

A fleet of autonomous submarines (L) carries out around-the-clock surveillance, using sonar, radar and video to detect intruders and inspect port infrastructure, while armed autonomous speedboats (M) patrol the surface. Unmanned surface vehicles (USVs) are already securing ports in the Middle East. But marine-control researchers at the Norwegian University of Science and Technology are working on smarter USVs that can make tactical decisions, work in formation, and autonomously coordinate with any other land, air or sea robots.



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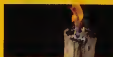
HOW 2.0

TIPS, TRICKS, HACKS AND DO-IT-YOURSELF PROJECTS



70

Stream your media
anywhere you want it



72

Turn tree stumps
into gunpowder



75

Torture-testing
project enclosures

YOU BUILT WHAT?!



A CLOSER VIEW

The hardest DIY project ever: a scanning electron microscope

Ben Krasnow has built his share of odd contraptions, including a liquid-nitrogen generator made from an air conditioner, and the "thirst extinguisher," a commercial-grade fire extinguisher that cools, carbonates, and dispenses his homemade beer. Now, for no other reason than wanting a real challenge, the 28-year-old engineer picked the toughest DIY project he could imagine: a homemade scanning electron microscope, or SEM. "I wanted to see if it was possible," he says.

Scientific labs will pay upward of \$250,000 for a high-end SEM, and as far as Krasnow could find, no individual had ever built one, so he had to improvise. He first spent a few weeks teaching himself the complex physics behind the instrument. Next he trolled eBay for cheap components, sorted through his home shop for power sources that might work, and then built what he couldn't find.

A typical SEM fires a thin stream of electrons at a sample, monitors the electrons kicked up by the impact, and translates the resulting signals into a picture.

Good, old reliability To keep the microscope's vacuum pump from overheating, Krasnow used an air conditioner from a liquid-nitrogen generator he had built previously.

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HOW 2.0 YOU BUILT WHAT?!

(CONTINUED FROM PRECEDING PAGE)

Krasnow made his electron gun out of a thin tungsten wire. He heats up the wire by applying a voltage, which releases clouds of electrons. The freed electrons speed through a thin copper pipe toward the sample.

In his initial tests, Krasnow had trouble aiming the electron beam onto the sample. Eventually he took a refrigerator magnet and moved it around the outside of the glass vacuum chamber that surrounds the microscope to adjust the beam's position. When

he got the beam focused in the right place, he taped the magnet in place.

The microscope now delivers about 50x magnification, a far cry from commercial SEMs' 1,000x or more, but microscope experts say that doesn't lessen the accomplishment. Chemist Robert Wolkow of the University of Alberta calls it "a wonderful achievement." And William Beatty, a research engineer and hobbyist who had also hoped to build the first DIY SEM, puts it more simply: "D'oh!"—GREGORY MOORE

HOW IT WORKS

TIME: 100 HOURS
COST: \$1,500

DISPLAY

The SEM gets its name because the electron beam scans the surface of the sample; the resulting image is basically a video of a still subject. To create that video, Krasnow bought an old oscilloscope. As the beam moves across the surface, the clouds of electrons emitted from the sample change, and the oscilloscope transforms this physical data into a video image. The catch with the oscilloscope is that Krasnow scans the image in 1/16 of a second to get a picture, and quicker scans result in lower-resolution images. He plans to digitize the system and replace the oscilloscope with a computer, which should allow him to scan slowly and increase the microscope's magnification.

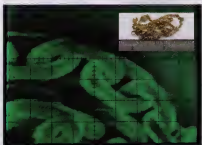
VACUUM COOLING

To maintain the microscope's thin beam of electrons, Krasnow had to eliminate any interference, so he housed the entire device in a large glass bell jar he had lying around. He used two separate pumps to create a vacuum inside the jar. One of the two has a tendency to overheat, so an aquarium pump sends engine coolant past the overheating pump, drawing out the heat, and cycles the fluid through a repurposed window-unit air conditioner, where it is cooled down before repeating the trip.

RETRO STYLE

The oscilloscope and two of the power supplies look as if they could have been salvaged from a 1960s space mission. Krasnow liked the aesthetic, so he enclosed the power supplies in a similar-colored rack, arranged the other components above them, bought blank gray faceplates, drilled the necessary holes, and mounted chrome toggle switches, red indicator lights, knobs and gauges that matched the style.

SHOW YOUR GOLD The image of a necklace scanned by Krasnow's microscope appears on the oscilloscope's screen.



UNDER GLASS The bell jar that houses the microscope's components



THE H2WHOA CREDO: DIY CAN BE DANGEROUS

We review all our projects before publishing them, but ultimately your safety is your responsibility. Always wear protective gear, take proper safety precautions, and follow all laws and regulations.

5 THINGS TO HELP YOU MOVE

1 GET PREPARED

Moving List (iPhone: \$3) and Moving Planner (Android: \$1) come loaded with checklists of crucial tasks such as scheduling utilities to be disconnected two to three weeks before you move and returning your neighbor's monkey wrench the week you leave. Check off each task as you complete it, and add your own.

2 GO POSTAL

Inform everyone of where you're going. At ChangeofAddress.org, you can set your forwarding address for mail posted to your old home, with the date it should go into effect. The site also provides links to forms for updating your information with the DMV, IRS and other government agencies, as well as hundreds of magazines.

3 PACK IT

Packing is hard. Finding what you packed is harder. With the iPhone Moving Van app (\$2), you photograph each item as you put it in a box, creating a searchable record. After the move, when you need to figure out where your rollerblades and waffle iron are stashed, the log indicates the correct box.

4 PLACE IT

Make sure all your belongings will fit in your new digs using the Smart Measure Pro Android app (\$1). Hold your cellphone at the preset height of just under five feet, and point the camera at two corners of a room. After measuring the angle from you to the corners, the app uses some trigonometry to calculate the room's square footage.

5 PARE DOWN

Too much stuff, not enough space? Donate the excess. At DonationTown.org, type in your zip code, and the site produces a list of charities in your area that will pick up your clothes, furniture, books and toys for free. With another click, you can schedule a vehicle to come haul it all away.—AMANDA SCHUPAK

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WIDEN THE STREAM

With a few tweaks, you can easily send music and video from an Apple iOS device anywhere you want it

One of the great features of Apple devices is AirPlay, the technology that enables them to wirelessly stream media to one another. The company has also set out to enable a growing range of other equipment, such as A/V receivers and speaker docks, to get content from your iTunes library simply by being near your computer or iOS device. Still, AirPlay has some Apple-imposed limitations, including the required use of iTunes and a relatively small pool of supported third-party devices. Recently, several tricks have been developed to extend AirPlay's functionality, letting you stream music and video to and from more places.—DARREN MURPH

EASY: SEND VIDEO TO YOUR MAC

One of AirPlay's major shortcomings is its inability to sling content to a Mac. A free app, *AirPlayer* (ericasadun.com/1ip/Macintosh), solves that problem by transforming your iPad, iPod Touch or iPhone into a video transmitter and allowing them to wirelessly stream iTunes clips to your Mac so you can watch on a bigger screen. The program works its magic by imitating the Apple TV's connection protocols. Note: This is not to be confused with another app called *AirPlayer*, which sells for \$5 in the iTunes store.

ENTERTAINMENT EVERYWHERE

Numerous device-to-device media-streaming configurations are possible using Apple's AirPlay, combined with some extra apps and hacks.

MEDIUM: ENABLE NON-ITUNES VIDEO-TO-TV STREAMING

With the content-management application Plex Media Center (free; plexapp.com) installed on your computer, the new Plex 1.1 iOS app (\$4.99 on iTunes) lets you search through all your media (not just iTunes content) with your iPhone or iPad, stream it over 3G, and channel it to a friend's HDTV via experimental AirPlay support. You'll need to enable a setting on your router known as port forwarding to connect devices outside of your local network; for instructions, head to wiki.plexapp.com. Note that purchased videos with digital rights management (DRM) controls cannot be streamed.

ADVANCED: STREAM TO ANY DEVICE

The biggest difficulty with AirPlay is having to buy hardware that supports it. ShairPort lets you keep your current gear. The software can be installed onto any PC, allowing any device to take advantage of AirPlay streaming. For now, this allows only streaming to third-party software, so you'll need a second computer to act as a go-between. For example, you could use your primary computer to stream music to VLC media-player software (free; videolan.org/vlc/) running on a home-theater PC, and then from VLC to an A/V receiver. You can get the ShairPort code free at mafipulation.org, but fair warning—using it may void your equipment's warranties.



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FIRE IN THE HOLE

Chemicals can turn any tree stump into virtual gunpowder

When you need to remove a tree stump, you have several options. Sissies call a tree service. Tough guys loop a chain around the stump, hook it to the bumper of their truck, and find out which one is stronger. Others use gunpowder to blow them up, though this is not advisable in most jurisdictions (unless your cousin is the sheriff and you let him watch). But my favorite method is to convert the stump itself into gunpowder and then burn it up. That is the secret behind how chemical stump remover works.

You might think you could just light stumps on fire and let them burn until they disappear. But since they're underground, there's no source of oxygen to sustain the flame. Even with kerosene soaked into the wood, the part of the stump under the surface won't burn. Gunpowder, on the other hand, burns even inside a sealed space because it contains its own source of oxygen in the form of potassium nitrate, or KNO_3 , better known as saltpeter. Get saltpeter into the stump, and it supplies oxygen to combust the wood.

Most common brands of chemical stump remover are nothing more than saltpeter. The instructions say to drill holes down into the stump, pour in the powder, and let it soak with water for up to a few months. This dissolves the saltpeter and distributes it throughout the stump. Then you soak the stump with kerosene and light it, causing it to burn all the way down to the roots with a fizzing, popping, purple-blue flame.

The stump's altered chemical composition—potassium nitrate combined with organic carbon—to produce heat and gas—is similar to gunpowder. That explains the unusual flame. The burn is slower, though, taking minutes instead of milliseconds to complete.

It might be surprising to discover that you can buy the key ingredient in gunpowder at any garden center. But here's the kicker: The other two ingredients are readily available as well. If you want to find out what those are, and read about my adventures making gunpowder, you'll just have to check out next month's issue.—THEODORE GRAY

SLOW BURN

Wood treated with stump remover burns with a purple-blue flame at and below its surface.



WARNING

Commercial stump remover is usually made of potassium nitrate plus a few impurities and stabilizers. Be sure to carefully read and follow the instructions on the label, because each brand is a little different.



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HOW 2.0 ASK A GEEK

WHY CAN'T ALL ANDROID PHONES USE ALL ANDROID APPS?

The Netflix app has been available on Apple's iOS and Windows Phone 7 since last year. When it finally came out for Android in May, some users found, to their great frustration, that it didn't work on their phones.

One reason for this problem, which affects a number of apps, is that Google has lax hardware requirements for Android phones. As a result, the phones have just about every variety of processor and amount of memory you can name. Power-intensive apps are often too much for older devices to handle. Android phones also vary in shape, size and features, so it's exceedingly difficult to release an

app that runs well on all of them.

Android's many hardware configurations also make it tough to create a uniform security platform. Part of why Netflix took so long to make it to Android was the high level of anti-piracy protection the company's content partners demanded. Differences in software versions could cause problems as well—some apps support only the most recent two versions of Android.

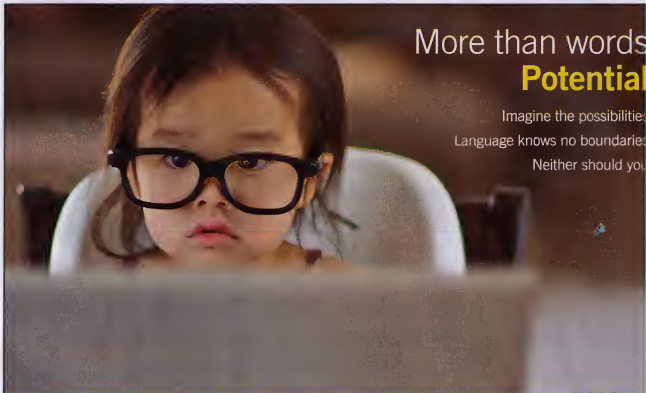
Google is making an effort to resolve these compatibility issues. Every phone with the next version of Android will have standardized software updates, and those phones will be able to run updated versions of Android for at least 18 months.

DAN NOSOWITZ

is PopSci.com's
assistant Web
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Conclusions: Plastic enclosures are good mainly for safe, indoor projects. Pelican cases keep out water but, surprisingly, fail the smash test. PVC junction boxes are the dark-horse winner; they're very cheap and rugged. Use one the next time you build something you plan to drop, drown, or set ablaze.—VIN MARSHALL

WARNING: Let us do the torture for you. Don't attempt to perform these tests or others like them on your own.

For more details, and video of the torture test, go to popsci.com/torturetest.



WATER

One minute submerged under three feet of water

IMPACT

A 30-foot fall from a forklift

FIRE

About a minute engulfed in blasts of propane flame

Standard plastic enclosure



Flooded

Smashed



Melted

PVC electrical junction box



Dry, but unclear how much more the lid gasket could be opened and closed

Chipped on the corners of the lid, but largely intact



No serious damage



Pelican case

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The Pain of Sciatica

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- ☐ Does the pain soon spread to your buttocks and into the back of your thighs?
- ☐ Does the intensity of the pain increase, and change from a dull ache to a searing, burning sensation?

It seems to strike just before you have something important planned, such as travelling on a plane or train, an activity requiring hours of sitting or bending.

That's why there's no GOOD time for a BAD back. So, let's examine what might be happening to many of you. Let's look at your back.



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Sciatica assaults the lumbar disk area of your spine. That is the area at the bottom of your spinal column. A slight hernia in the disk compresses the sciatic nerve. Until now, the most common treatment is restricted movement and warm compresses. Yes, good old *rest and heat*! But there is a new answer!

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- Belladonna: Reduces inflammation.
- Camomilla: Reduces those tearing and pulling pains in your lower back.
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- Gnapaphalium: Reduces the pain transmitted by the sciatic nerve.

perform normal tasks returns faster than you thought possible. If you want to feel good again, without the searing, numbing pain of a sore lower back and upper thighs, you need to try SciatiCalm.

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FYI

STUFF YOU JUST NEED TO KNOW



78

Skittles has the sniffles. But why?



Q WHAT IS THE MOST DANGEROUS PIECE OF LABORATORY EQUIPMENT?

A Consider the autoclave, which scientists use to sterilize tools—and which issues scalding steam to do so. Or consider the heat gun, which is used to dry glassware and to warm distillation devices. It can also ignite anything flammable that gets too close. Glass containers in a vacuum can implode, spraying shards everywhere. Centrifuge rotors can fail, causing explosions that throw

shock waves throughout a lab filled with chemicals. Steel vessels built to contain liquids and gases at hundreds of pounds of pressure per square inch can rupture, hurling metal at lab workers. Yet none of these instruments is nearly as dangerous as the only thing found in every single laboratory on earth: us.

When lab accidents result in death or serious injury, human error is usually to blame. In 1997, Elizabeth Griffin, a 22-year-old

primate researcher at Emory University, wasn't wearing goggles when a rhesus monkey flung feces into her eyes. She died of complications from herpes B six weeks later. In 1996, chemistry professor Karen Wetterhahn inadvertently dribbled some dimethylmercury onto her gloved hand during a routine transfer in a Dartmouth College lab. It seeped through her glove and, 10 months later, she died of mercury poisoning. And in 2009, Sheharbano Sangji, a 23-year-old lab assistant at the University of California at Los Angeles, wasn't wearing the required flame-resistant lab coat and died from burns after a chemical fire ignited her sweater.

All these accidents, you may have noticed, occurred at schools. James Kaufman, president of the nonprofit Laboratory Safety Institute, says that the rate of lab accidents at schools and colleges is up to 100 times that in the chemical industry. Although educational labs are far more dangerous, the exact number of accidents is impossible to know. The U.S. Bureau of Labor Statistics only records accidents in professional labs. While Dow, DuPont and other chemical manufacturers enforce rigorous safety programs, the safety policies at universities are often communicated to lab workers through anecdotes and unsystematic verbal warnings. And school labs are full of inexperienced workers: students. After Michele Dufault asphyxiated in a Yale University machine shop the night of April 12, speculation centered on the safety precautions taken by the undergrad. Working alone, she was strangled when her hair caught in a lathe.

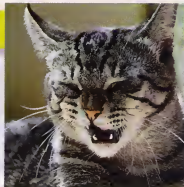
The routine tasks that killed Griffin, Wetterhahn, Sangji and Dufault are actually statistically more dangerous than the supercolliders or the biosafety-level-4 hazards that cannot be handled without moon suits. Part of the

reason is that fewer people are exposed. Just as important, the more dangerous the equipment at a lab is, the more exhaustive the safety program. At the Integrated Research Facility at Fort Detrick, Maryland, researchers wear sealed biohazard suits and take decontamination showers lasting seven minutes. Automated air systems ensure that potentially contaminated air cannot escape the rooms that house the Ebola and Marburg viruses. Reminders of the extreme danger are ever present, so scientists never get too comfortable. Gigi Gronvall, an immunologist at the University of Pittsburgh's Center for Biosecurity, says that "the most dangerous thing is human error, and the highest-containment labs are much less likely to have it.

—JOSEPH A. BERNSTEIN

MEOW-CHU!

Feline allergies are caused by the same triggers as human allergies. Pets can even be allergic to people or, more likely, the chemicals on our skin.



Why is my cat so sneezy?

Cats get seasonal allergies to pollen and grass, and some have year-round allergies to fleas and dust mites. Sandy Willis, a veterinary internist who advises the American Veterinary Medical Association, says that when cats interact with an allergen, their body sends immunoglobulin E antibodies to link with it, triggering the release of histamine and other chemicals that cause itchy eyes, runny noses, sneezing, hives and rashes. The same process happens in other pets (dogs, rats, hamsters)

and humans. In rare cases, cats can even be allergic to people. Pet allergies are uncommon, since cats bathe more often than most species and don't shed as much fur and dead skin—which triggers their own allergies to pets. When cats do have a bad reaction to us, it's usually caused by residue from perfume, soap or laundry detergent. Any water-based cleaning product usually contains some preservatives. Cats tend to be more sensitive to chemicals than dogs. Specific cat allergies are difficult to isolate and diagnose, so pets can't be treated for them or build up tolerance with exposure like they can for organic allergies.

Cats can even be allergic to people. Pets offer antihistamines: dogs to treat cat, horse and bird allergies. Cat antihistamines recently hit the market too.—LIZZIE SCHIFF

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CONTINUED FROM PAGE 571

THE MAN WHO WOULD STOP TIME

herbs been activating their telomerase without knowing it? Anderson, a self-described nutraceutical research scientist and medicine hunter, demurs, saying only that his nonchemical extraction and refining process concentrates and enhances any healing properties they may have previously exhibited. As Jon Cornell, Andrews's administrative lieutenant at Sierra Sciences, says, if herbs and roots naturally had the level of telomerase-inducing activity that Andrews and his team are really looking for, "we'd probably already have immortal people."

Andrews leads me through a succession of compact lab rooms, each of which contains more equipment than people to run it. (Since 2008, he has cut the number of staff scientists from 34 to eight.) The center of the complex is a single cramped room where a couple of cell biologists and lab techs tend to plastic flasks holding millions of human fibroblast cells. The cells will be transferred to tiny plastic vials, frozen in liquid nitrogen, and then, when their number is called, thawed and bathed for 24 hours in one of Anderson's natural ingredients. Then they're whisked across the hall, where another small group of scientists and techs run a production line that sends plates of the treated cells through a LightCycler analyzer, which amplifies what's going on at the molecular level using PCR (polymerase chain reaction, better known as the perp-catching technology on *CSI*). Telomerase is made up of two components—the RNA, which serves as a template to be used by the second part, a catalytic protein that synthesizes the DNA added back to telomeres. The LightCycler scans for RNA activity suggestive of telomerase expression. Promising compounds are then run through a slower, by-hand assay to look for hard evidence of the protein at work. "It's cherry picking," Andrews says. "The machine selects the reddest cherries."

The analogy sounds so delightful that it's jarring to remember that the measuring rod, the "standard control" the lab uses to evaluate telomerase activity in test compounds, is cancer—specifically the HeLa cancer cells that were the first cell line to achieve immortality. Back when Andrews

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THE OBSESSIVES

THE MAN WHO WOULD

was working with the more potent synthetic chemicals that he says were, in theory, capable of putting the brakes on aging, his team was able to get one compound up to a 16. That would be 16 percent of the telomerase required to make the HeLa cells live forever. "What we really want to do is to get it to 100 percent and above," he says.

TELOMERASE, as Blackburn once noted, is a Dr. Jekyll and Mr. Hyde proposition. Though it will not cause a cell to turn cancerous by itself, telomerase in its uncivilized Mr. Hyde mode does fuel the unregulated growth of most cancers. By activating the enzyme, Calvin Harley says, "there is a risk, a small probability, that it could cause a premalignant cell to divide enough times to become malignant." But both Harley and Andrews say they believe that any increased cancer risk is outweighed by the potential rewards. Telomerase can also be a benign Dr. Jekyll that protects against the chromosomal breakage and re-fusion that can lead to cancer, and it can help drive the proliferation of immune-system cells whose job it is to fight cancer. A study in the July 7, 2010, *Journal of the American Medical Association* highlighted the correlation between cancer and short telomeres: People with shorter-than-average telomeres had three times the risk of developing cancer and 11 times the risk of dying from it. Andrews is not shy about talking with cancer patients—seemingly the group most vulnerable to the Mr. Hyde risks of runaway telomerase—about the potential health advantages of telomerase activation. "I'm always careful to qualify that I'm not an M.D., I'm not able to provide medical advice," he says. "I do say that if I had cancer, I'd be taking as much telomerase activator as I could get my hands on."

As it happens, he already is. In 2002, a New York City entrepreneur and former appliance manufacturer, Noel Thomas Patton, licensed the rights to Geron's research on a telomer-

ase-activating compound found in the Chinese medicinal herb astragalus, for supplement use only. (Geron is finalizing a plan to send an astragalus-based telomerase-activating drug candidate through clinical trials.) Three years ago, Patton's TA Sciences test-launched its TA-65 supplement with 100 clients, each willing to pay \$25,000 a year to be anti-aging guinea pigs. Paying patient number one: Bill Andrews.

TA Sciences has this year ramped up production and dropped the stratospheric price tag, although so far the most impressive effects remain anecdotal—more energy, greater mental clarity, a sexual boost, even improved vision. Andrews says his ultramarathon times dropped when he started taking TA-65. An observational study co-authored by Harley, who helped discover the original molecule at Geron, found improvements in the immune system of those first 100 clients. Andrews was hoping for a more pronounced effect. As he describes what it was like to take that first dose of the supplement in 2008, I can hear the voice of a kid who hasn't entirely grown up, anti-aging as a never-ending Hardy Boys adventure: "I remember Noel and I sitting having dinner, and we were wondering, What are we going to look like two weeks from now? We talked on the phone practically every day, and we were both disappointed that we didn't look any younger right away."

Andrews's tendency to let his enthusiasms take him out on a limb, especially when he's trying to attract investors, makes him a polarizing figure in the research community. To some academics, his standard pitch-cum-sound-bite, "We age because our telomeres shorten," is a crude oversimplification. Even Andrews seems to suspect that Sierra Sciences's company motto, "Cure Aging or Die Trying," isn't winning him many friends among people who possess advanced biology degrees. "Some people like it and other people say it's embarrassing," he says. "So I don't know what to do."

STOP TIME

I later ask Federico Gaeta, Geron's former head of chemistry and a current Sierra Sciences consultant, whether Andrews's reputation has suffered for his damn-the-nuance pursuit of longevity. "Unequivocally, he's paid a price with his scientific peers," he says. "How big a price, I don't know, but there is an excellent chance that he will ultimately be vindicated." Now, Gaeta says, "he's in a position where he has to show that he's done something." The years of angels with blank checks are over, and the pressure to produce—and to raise the money to buy the time to produce—is tremendous. "He's not going to break," Gaeta says. "I know that about him. Bill's not going to break."

BY 5 P.M., midwinter darkness is beginning to fall, and the skeleton crew at Sierra Sciences is mostly gone, though Andrews is looking at another long night that will probably end on his makeshift bed. The last employee to leave is Randy

Lee, the IT guy, an old Southern California prep-school buddy of Andrews's. He's been hanging around because he has some bad news to deliver. Lee has the unenviable job of reconfiguring the lab's now inadequate computer system. Today he lost a cache of valuable data when the system crashed. When he delivers the news, Andrews visibly compresses, as if another 10 pounds has been added to the weight already on his shoulders. Then he collects himself. "I told people we're either going to never move forward with our system or we're going to take the chance of losing things," he says. "Well, try to get a good night's sleep. I'm sorry for your sake that it happened."

After Lee heads for home, I ask Andrews to consider a hypothetical. If I wrote him a check for \$10 million, would that be enough to send him back to the lab to find that home-run telomerase-activating chemical? "No," he says, "but that would increase our chances of getting a really good natural

product that nobody could compete with. To do the pharmaceutical, we'd need \$30 million." I toss out a flip rejoinder—"Sorry, Bill, I can only do the \$10 million"—and Andrews freezes for a half-second, then slumps back in his chair. "I've got business plans that have all that budgeted," he says. "What the money would be used for."

I ask Andrews what the worst-case scenario would be for Sierra Sciences. "The worst-case scenario," he says, "is that we put out a telomerase activator and everybody who takes it dies right away."

"No," I clarify, "the worst-case financial scenario?"

Andrews, his voice phlegmy with fatigue, tries again. "The company folds. I find another job, but I still work on trying to find more investors to resuscitate it. I can't be happy unless I'm working on this. The mission won't die unless I die."

Joseph Hooper is a contributing editor at POPULAR SCIENCE.

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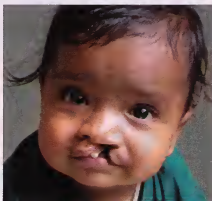
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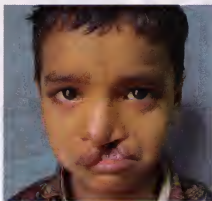
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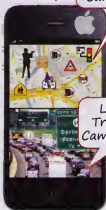


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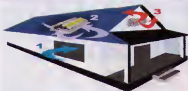
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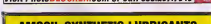


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THE FUTURE THEN

FROM THE POPULAR SCIENCE ARCHIVES

APRIL 1934

Designed for Speed

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In the 1930s, "streamlining" was the trend in car design—a flashy mark of modernity. But for New York industrial designer Norman Bel Geddes, streamlining was a way to speed up oceangoing ships and cut a transatlantic trip by a full day.

Bel Geddes described the ship that made the cover of our April 1934 issue in his book on the future of sea travel, *Horizons*. A sleek shell would cover the 1,088-foot passenger liner, reducing wind resistance by as much as 80 percent. In good weather, panels could be opened to allow the ship's passengers to stroll the exposed deck. With the panels closed, however, the ship would be "as impervious to the elements as a submarine." Bel Geddes's ship was never built, but his ideas on aerodynamic design had a lasting influence, eventually informing the shape of such iconic cars as the Volkswagen Beetle. Ships, meanwhile, have gotten bigger and faster than he could have imagined. Go to page 38 to see what we mean. —NADMI MAJOR



The Biggest Ships Keep Getting Bigger

AUGUST 1954 Seascraper

At 1,039 feet long, the \$217-million aircraft carrier USS *Forrestal* was just seven feet shorter than the Chrysler Building.

MARCH 1960 Atomic Carrier

The world's first atomic aircraft carrier, the USS *Enterprise*, was 1,100 feet long, with room for more than 70 aircraft.

JULY 1972 Supertanker

At 1,139 feet, the *Nisseki Maru*, launched in 1971, is almost quaint by today's standards. Tankers now exceed 1,500 feet.



The *Nisseki Maru* was the largest tanker yet when it was launched in 1971.



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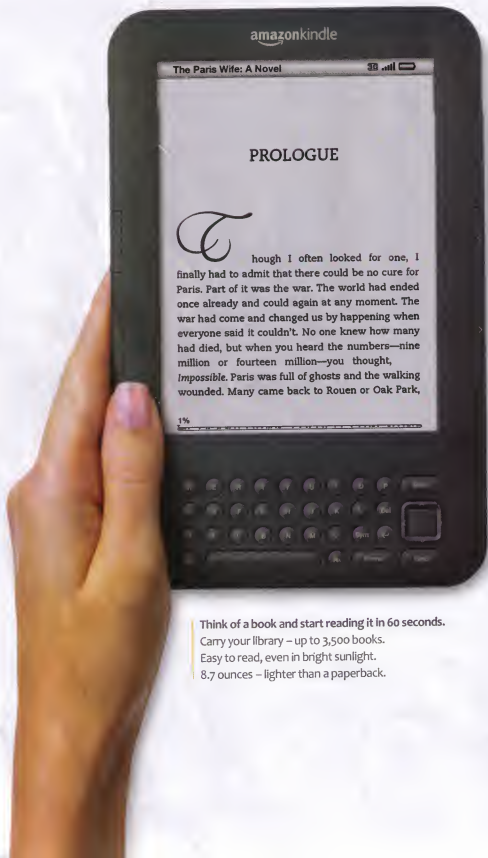
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